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OPERATION DEEPFREEZE I

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I WANT FIRST, in this paper, to stress that though I shall not say much about the International Geophysical Year, everything I do say relates to the furtherance of that enterprise. At the beginning of last season the Americans, unlike ourselves, had no stations in the Antarctic, but they had a very ambitious programme which envisaged the setting up of seven such stations. "Deepfreeze I," their first expedition to the Antarctic since Operation "Highjump" in 1946–7, had as its object the setting up of the first of these bases, Little America and McMurdo. The following year, in the course of "Deepfreeze II," the other five would be set up—Byrd was to be the offspring of Little America, and South Pole of McMurdo, while the remaining three were planned as coast stations of moderately easy access. Tonight I am concerned only with the first year, but I shall refer to the second year as "next season"—though in fact it started about three weeks ago [in October 1956].

The agency selected to run Deepfreeze was the United States Navy, always to the fore in American Antarctic exploration; and there can be few other agencies with the necessary equipment and with the capacity to cope with such a large undertaking. The doctrine, and most of the men and materials, were supplied by the Navy, as was the commander Admiral Dufek. Admiral Dufek has the distinction, I think, of being the only retired officer ever to command an operational force. Admiral Byrd, who was with us, was in general charge of the whole United States Antarctic programme. Descending very rapidly in the hierarchy, there was myself as United Kingdom observer, and observers from about five other countries; we had no expeditionary duties at all, so could see a tremendous amount of this latest example of mechanized exploration. The waterborne forces consisted of three icebreakers. Two were in the "Wind" class (*Eastwind* and *Edisto*); one was run by the U.S. Navy and the other by the U.S. Coastguard Service. This type has been in service for about ten years. The third icebreaker, *Glacier*, was the U.S.N.'s largest and latest model, said to be the most powerful in the world. I was snugly and very safely aboard this ship and endeavoured to remain that way throughout the expedition. There were three cargo ships, each about the size of a Liberty Ship, and completing the ship forces were three tankers. One was a small vessel carrying about 500,000 gallons of aviation petrol, and the other two were even smaller, small enough in fact to be towed all the way from America by the icebreakers. The airborne forces, which were all naval aircraft, consisted of eight land-based aircraft and four De Havilland Otters, this latter type being a Canadian aircraft with a ski-wheel combination a little bigger than an Auster. Seven helicopters, carried for the most part in the icebreakers, made up a total of nineteen aircraft. The land forces

consisted of a special naval construction battalion of 200 men, of whom 150 were to form the wintering parties at the two completed bases.

There was plenty, and a great variety, of equipment; to begin with, we had twenty-five tractors, costing in all around a million dollars! The sleds were proportionately large compared with the tractors; they weighed about 10 tons and carried twenty. There were also light reconnaissance vehicles such as Dr. Fuchs

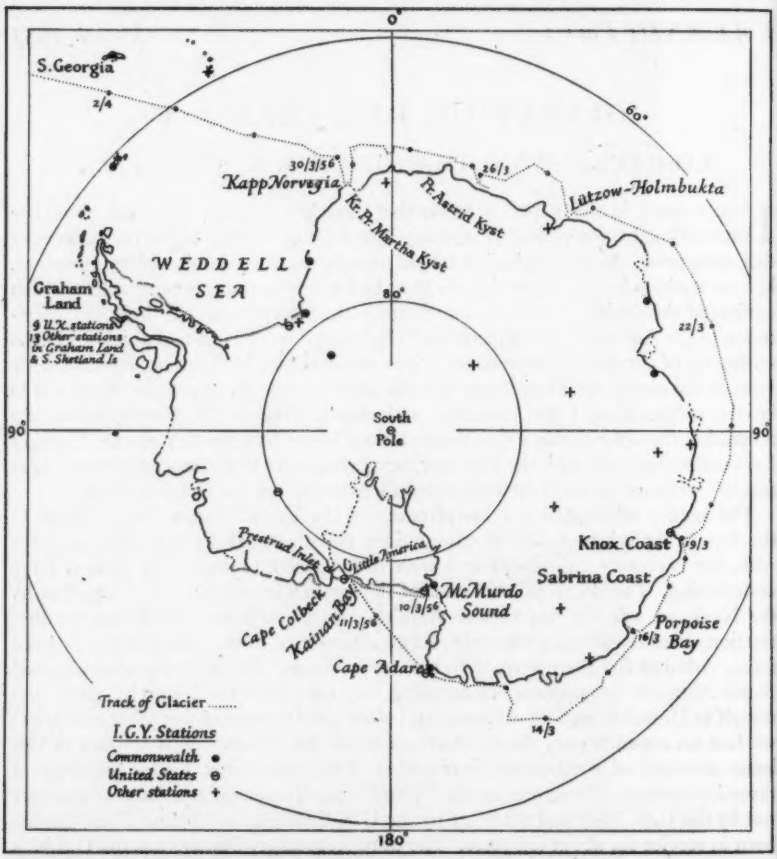

Fig. 1. Antarctica showing I.G.Y. stations: trail-finding route Little America–Marie Byrd plateau; return route of Glacier

will be using—Snocats and Weasels. Aircraft runways were to be built, and equipment for doing that included the "Pulvimixer," a machine that grinds up the snow like a flail on the front of a tank, and follows up with a 5-ton roller. Lastly, I must mention the cargo. There were buildings for camps, and all the necessary accoutrements for those camps, including generators and furniture for the buildings, radar, food, pianos and even refrigerators! Small crates were packed together into large crates, or "palletized" to make cargo handling a fairly simple job. The total weight

of stores was about 10,000 tons; the icebreakers carried what was needed by the advance parties, and the rest went in cargo ships. The total number of men on the expedition was in the region of two thousand, probably the largest expedition that has ever been mounted against the Antarctic, though I am not sure of the size of the Russian expedition that was going on at the same time.

I am first going to give an outline of the whole expedition and then go into more detail about the various parts separately. Although I will thus divorce the phases, I must stress that they were integrated. The scientific work of the expedition was this year of secondary importance, and I do not intend to deal with it very fully, but the following notes may be of interest. Oceanography: all ships carried echo-sounders, and continuously used them while they were under way; selected ships made casts for marine life, temperature gradients with depth, and water samples—all part of the marine biologist's programme. Meteorology was a necessary part of the plans, because of the air operations we were carrying out, but it took a practical rather than a scientific form. Seismic soundings were made in several places on the edge of the ice cap to ascertain thicknesses. One ship carried a cosmic ray apparatus, and claimed to be "delineating the geomagnetic equator." Little survey work was done and nearly all the photographs taken by the big aircraft were of the exploratory type.

The ships and aircraft left the east coast of the United States in November 1955 and crossed the Pacific independently to New Zealand. In the middle of December 1955 the icebreakers sailed south and established a very small camp near Scott's hut in McMurdo Sound. This was for the heavy aircraft which flew in from New Zealand immediately the camp was ready. After this, *Glacier* went north and escorted the cargo ships, which were waiting at a little island (Scott Island) which is the traditional entry point for the pack ice. There was only need for one ice-breaker, for the pack was only about 4 feet thick and not very dense. They broke through to a large shore lead, something like 80 to 100 miles of clear water, where it was possible for cargo ships to move without icebreaker escort. *Glacier* took two of the ships east to Kainan Bay, and the remaining ones went to McMurdo Sound.

A suitable base site was quickly chosen at Kainan Bay, and the unloading of stores and building of camp proceeded very quickly. At the same time preparations were made for a trail party to find a route up to the prospective station "Byrd" on the Marie Byrd plateau, an offshoot of the main scientific station of "Little America" in Kainan Bay. Meanwhile the aircraft had made flights from centres on McMurdo, ranging right across the continent. As soon as these were over, they left, and the ships at McMurdo were able to concentrate fully upon unloading and building the airbase at the Sound. This base will be used for next year solely as an airbase. It is not a scientific station, though there may be a few scientists there, but a jumping-off point for the station directly at the South Pole. South Pole station will have a population of about seventeen, but we took all its stores to McMurdo, and next season heavier aircraft than we were using will fly into McMurdo Sound, pick up the stores and drop them at the South Pole by parachute. This was planned for October 1956,[1] a time of year when there is light and warmth enough for work, but earlier than the generally accepted date for penetrating the ice. The earliest date for getting through is usually held to be late December, but I myself, having travelled in *Glacier*, have my doubts—I think she can get in a lot sooner. As I

[1] The South Pole base is now established, the advance party having arrived by air on 20 November 1956, with dogs and a sledge; further supplies were coming in by air (*The Times*, 22 November 1956).

have said, seven bases were projected, and icebreakers *Eastwind* and *Glacier* made surveys for the remaining three.

Now for the work that went on at Little America. The U.S.S. *Atca* had done a survey in this region during the previous season (1954–5) and estimated that Kainan Bay was the only possible site for the proposed station. Kainan is a bay about 2 miles square, formed by the edge of the barrier ice, which is anything from 50 to 100 feet high. The whole bay was covered with sea ice when we found it, but there existed in the south-east corner a nice snow ramp landing onto the barrier. It was along this route that the stores were later carried to the camp site, just below

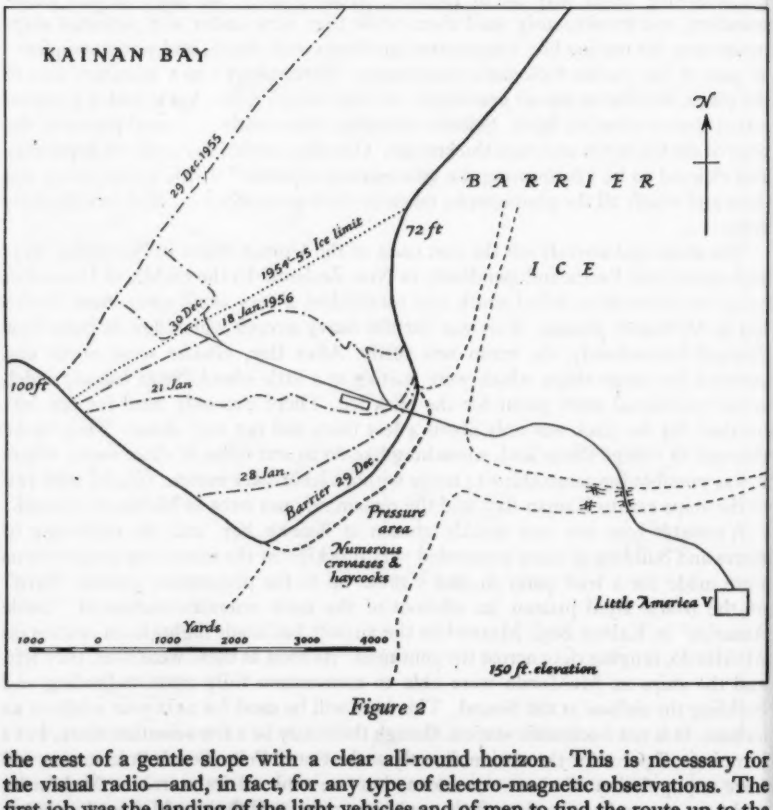

Figure 2

the crest of a gentle slope with a clear all-round horizon. This is necessary for the visual radio—and, in fact, for any type of electro-magnetic observations. The first job was the landing of the light vehicles and of men to find the route up to the camp site; Snocats were unloaded, and they set off with men leading on skis over sea ice 8 or 9 feet thick. While they were doing this, *Glacier* was taking about a day and a half to break into the small bay (marked 30 December on Figure 2) and so bring us up to the 1954–5 ice limit reached by U.S.S. *Atca*. This was our first taste of heavy ice-breaking. The technique was to take a run of up to 800 yards, and impact the ice, at a speed sometimes of 17 knots, but more normally twelve, and get brought up in maybe 50 to 200 feet. It was a very noisy operation, but one got used to it, and I found it particularly exhilarating. A lot of debris was produced, but

with a southerly wind luckily most of it went out to sea, and we were able to bring in the cargo ships and berth them alongside the slightly rugged edge. The small landing craft carried by the cargo ships were used to fend off the odd blocks of ice that did come into the bay and which menaced their comparatively thin skins. As soon as the cargo ships had berthed they started to unload to the dump about halfway to the barrier; it was not possible to unload the whole way as the trail was not immediately complete up to the camp. The trail-finding party had located cracks in the sea ice and they had also found, which was more serious, crevasses possibly 80 to 100 feet deep in the barrier ice. The sea ice cracks were easily bridged with the aluminium bridging equipment that *Glacier* carried. The deep crevasses presented a greater difficulty, but it was solved by filling them with snow, and the vast quantities necessary were pushed in by the heavy tractors with their mammoth blades. The whole process of trail-making took about five days, so that on January 3 vehicles of all sizes could get up to the camp. On this day the camp, consisting only of a few shelter tents, was formally commissioned in the presence of Admirals Byrd and Dufek. About five days later the sea ice was weakening noticeably and the weather, I think, was fairly warm, much warmer down there probably than it was in England at the time. That was all very well, but the ice was melting and a rush evacuation was necessary of the stores still on the sea ice halfway to the barrier. Two days after it had all been shifted, the ice broke away to a large extent. This had the advantage of allowing the cargo ships to move nearer to the south-east corner. From then on all stores were towed away as soon as they were landed, and no stores were landed unless there was something to take them away in. Unloading was done on a twenty-four hour basis, using two shifts working twelve hours each. There were plenty of men at work—some were employed in the ships unloading, some driving the tractors, and still there were a handsome number available for building the camp. Constant vigilance was required to watch for ice breakaways, and in the end twenty-four hour patrols were instituted, with men on either side of a crack listening and looking for any danger signs. The other unloading difficulty was the maintenance of the trail, for the constant procession of heavy loads left deep ruts, and about two of the big tractors were needed to keep the 2 miles of the route graded. As soon as it was possible to get materials to the camp site (that is, commissioning day) the actual construction started. The ground was quickly levelled by bulldozers, small timbers were laid to take the aluminium trusses on which the panel for the floor was laid and the side panels were erected. All the buildings were of the same panel construction, though some were of different sizes. Providing all material was at hand, it took about 120 man-hours to erect each building. The first to be completed comprised the living quarters, and after them came the galley, the mess-hall and the washrooms; then they put heat inside them, and then came the fittings. As for the buildings for scientific and mechanical purposes, which brought the total to twenty-two in this particular camp, there was no hurry for these and they came last, after the ships had left.

We had arrived on December 29, and by January 23, in a little less than a month, all the 5000 tons of cargo had been landed and the camp was sufficiently well advanced for the men to be self-sufficient. They were comfortable in their huts, and they had everything they needed to see them through, except the bulk fuel supplies which were landed within a week. Little America, as I have said, is the main scientific station, and it has an offshoot on the plateau. It is planned to construct this subsidiary station next season and to take all the 500 tons of stores over the ice. Our expedition's job was to find a route to the proposed site and lay

fuel depots along it, which could be used by the main cargo-carrying tractor trains. The trail-finding party consisted of ten men with three vehicles, that is, one Weasel (which had complicated navigational equipment) and two Snocats. They had the support, in the first stages, of a helicopter, and throughout of a De Havilland Otter. The leading Weasel was fitted with an electronic crevasse detector—a very efficient machine which they say can not only detect crevasses but tell their size. Some crevasses are open, and that is just too easy, but most are closed, with a thick snow bridge concealing the depth. To get over such a snow bridge is probably quite easy on skis, or walking, or with dogs, or even with a light vehicle, but with a heavy vehicle it is an odds-on chance that it will go through and the heavier the snow bridge the more difficult it is to detect by eye or by patterns on the snow. When a crevasse is detected it is blown open, and then filled right up by shoving snow into it with the tractor blades. (See Figure 1 for route up Prestrud Inlet.)

The route-finding party left in the middle of January, some three weeks after they had hoped to leave, and were about 80 miles to the east of Little America when they came on crevasses. They made a detour round the crevassed area and went up the Prestrud Inlet. About there they began meeting crevasses again and unfortunately lost the services of their electronic toy. However, they pushed on up without too much difficulty, and as soon as they were on the Marie Byrd plateau, they had no trouble at all and simply screamed along to what is known as "Cache No. 7" where they stopped. I believe this was because they had used more fuel than they had bargained for and so they schemed to leave the vehicles at Cache No. 7 and ferry all the ten men back by Otter. On the first flight the Otter crashed and an extensive search operation was set in motion. The vehicles at No. 7 were in quite a good position, so they back-tracked with the remaining members of the team, and the crew and passengers of the crash were eventually rescued. About the time of the crash the first fuel-laying tractor train set off. This consisted of about five heavy tractors, each towing two 20-ton capacity bob-sleds loaded with fuel drums. They followed the trail quite successfully and could see the markings of the snow-bridged crevasses, but their progress was not very fast owing to the work necessary to make the crevasse crossings safe. This means unhitching the tractors, which is not an easy job—it takes three or four men to do it—dynamiting and then filling the crevasses, then hitching up again and driving on. Eventually the fuel-laying train reached a point on Prestrud Inlet just beyond "Cache No. 2" where, unfortunately, they lost one tractor, with its driver, down a crevasse which they were filling in. They deposited their load and returned to Little America. Thus the situation at the end was that fuel had been laid to Cache No. 2, at the foot of the rise of the Prestrud Inlet, just where the route starts going up to the plateau, where crevasses are liable to be bad. It is planned to fly new crevasse detectors down there next season but they still have the paramount problem of time. They must still fill in the crevasses and make them safe, and the fuel depots will have to be laid by these same tractors which will have to go back and collect the main cargo. *Glacier* did not remain long at Little America and we left as soon as the ice-breaking was complete and the cargo ships had started to unload. We did, however, have New Year's Eve there, when we landed on the ice and had a beer party. There was a New Zealander there as well as myself—we were the only "limeys"—and we were distinguished during this party because we had the beer inside our clothes to keep it warm, while the Americans put it in the ice to keep it cold.

We now made our way along the seemingly everlasting barrier going westwards until we came to Ross Island. Ross is dominated by Mount Erebus, which is the

Glacier *at full power, making about three k*
through conglomerate pack ice off Cape Fresh

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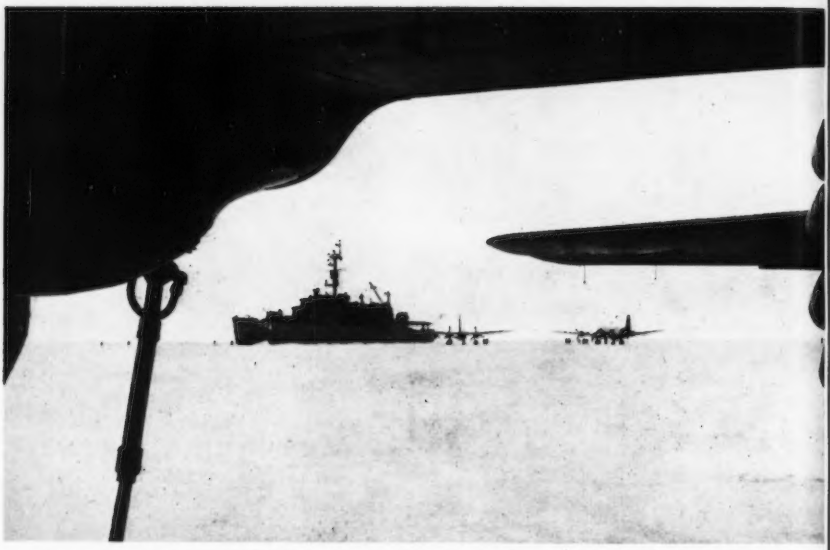


Glacier *refuelling a P2V (Neptune) and R5D (Skymaster) in McMurdo Sound*

Tankers moored at Hut Point

only known active volcano in the Antarctic, and the topography here was the most photogenic that we found. On the north side of the island, to the east of the entrance to McMurdo Sound, there was a grounded iceberg about 20 miles long; the corner on which it was grounded on the north-east had a peculiarly shaped front which gave us the idea that it was ice knocked off the bottom. So large an iceberg in this position may have affected the currents in the area and thus influenced the amount of ice we found in McMurdo Sound, which was greater than we expected. (See Figure 3.)

We had hoped to put the base camp at Hut Point, the site of Scott's 1902 hut,

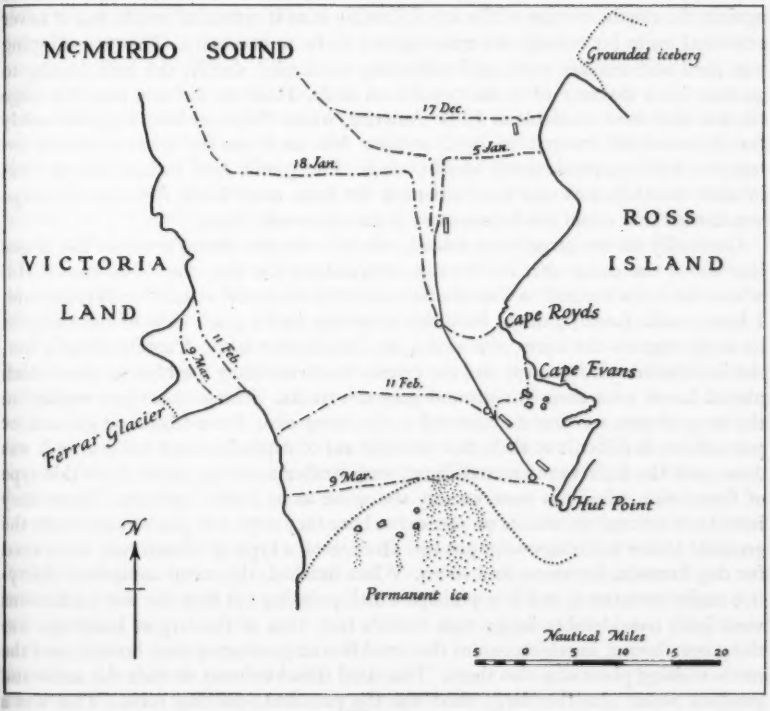


Figure 3

near the permanent ice where the runway was to be constructed, and we realized this was going to be a stiff job with 40 miles of fast sea ice between where the cargo had to be landed and where the ships were. It is no good putting runways on the sea ice, for it does not come in and out to a schedule—one year it will be solid far out, the next year it will go in; we had to get as near as possible to the permanent ice, for only there would the runway be safe. Not only was this 40 miles of sea ice rather a long way for the tractors, but there were cracks extending right across the sound. One attempt to drive in the tractors resulted in the loss of a vehicle and its driver through the ice, and no further attempts were made. Breaking was immediately started by *Eastwind* and *Edisto*, but it was not until *Glacier* arrived that real

progress was made. There is quite a lot of difference between a 6300-ton icebreaker of the Wind class and the 8600-ton *Glacier*. It is not so much the thickness of the ice that matters, it is the amount of ice cover, and we were confronted with solid sheet ice. The channel broken by *Glacier* was a narrow one, and from the quarter-deck one had a view of cakes of ice, some 6 feet thick, barring the way; from the top of the mast one could see the channel wriggling away in the distance, and could realize that one does not have all that control over direction—one goes rather where the ice tells you. The channel, choked with debris, allowed only icebreakers to proceed up it, and in order to get the cargo ashore it all had to be transhipped from the cargo ships to the icebreakers. The cargo ships came to against the northern edge of the ice, following it as it retreated south, but it never retreated quite far enough for transhipping to be unnecessary. This transhipping was hard and tedious work, and unloading proceeded slowly, the bulk having to go over ice a distance of about 5 miles on sleds. Here we did not have the large tractors that were available at Little America, where they had been supplied solely for the overland traverse to Byrd station. We used smaller tractors, about 10-tonners, with proportionately smaller sleds. The 5-mile haul rather than the icebreaker transhipment was the bottleneck for here, as at Little America, no cargo was landed that could not be removed at once to a safe place.

Gradually all the cargo went ashore, where a sizeable dump grew on the slopes just above the camp site. At the top, overlooking the site, was Observation Hill where the cross erected to Captain Scott and his team still stands for all to see and, I hope, read. Looking down from this cross one had a good view of the camp in its early stages—the camp, the stores, the freshwater lakes, Captain Scott's hut, the icebreakers 5 miles away and the tractor route avoiding the blue ice area which played havoc with their low-ground pressure tracks. Strange machines worked in the cargo dump, moving the material to the camp site. Frost-hardened ground, or permafrost, is difficult to shift, but with the aid of explosives and bulldozers it was done, and the huts were erected direct onto timber footings; apart from this type of foundation, the huts were exactly the same as at Little America. There they have been erected on trusses on the snow, here they were just put straight onto the ground. Other buildings were put up: Quonsetts, a type of Nissen hut, were used for dog-kennels, for stores and so on. When finished, the camp comprised thirty-five major structures, and it is perhaps worth pointing out that the two washrooms were both considerably larger than Scott's hut. One of the largest buildings was the power-house, in which two of the 100-kilowatt generators were housed, and the snow-melting plant was also there. This used diesel exhaust to melt the snow and produce water. Another large shed was the parachute-packing room. This was a most important place because the 250 tons of cargo in the dumps at McMurdo, destined for the South Pole station, will all be dropped from the air and the correct packing of the parachutes and their protection from moisture is most essential.

I have probably given a misleading impression by making the McMurdo Sound phase sound too simple; it was easily the most complicated and difficult! The inability to predict weather and ice conditions was one cause of this, and that factor remained with us all the time. There were odd side trips too—for surveying and various purposes—and one I went on was to Scott's hut at Cape Evans, where he was in, roughly, 1911. This hut was used by Shackleton's Ross Sea party on his Trans-Antarctic Expedition and we took a picture through the only window which gave a view of the inside.[1] If one had been very small (and very warm) and

[1] See *Georg. J.* 122 (1956) p. 527.

had taken off all one's clothes, one could have wriggled through the pane, but I preferred to remain warm. The Ross Sea party was relieved on 17 January 1917 after being stranded here, and they were so keen to get out that they left everything just as it stood. They were just about cooking up a meal, I think; we could see a loaf of bread that had been there thirty-nine years, a weighing machine and tins, not to mention two potatoes. Scattered on the table were virol, a bottle of wine, sweets, salt, a coffee pot, and on the wall photographs of our then King and Queen —King George V and Queen Mary.

The final stage at McMurdo came towards the beginning of March, and in a last two-day fury of ice-breaking we broke through to Hut Point itself. This was definitely our heaviest ice-breaking—it took us two days to go 2 miles and at times we were meeting ice that was estimated to be 23 feet thick; that is, of ice and snow compaction on top of that. The ice came away until we were right at the land, and able to secure our two small tankers to a nice ice wall. This was late in the season, and a week after they had been in position, they were firmly frozen in for the winter, each containing about 500,000 gallons of fuel. They were conveniently next door to the big fuel tank, ready to act as a petrol station for next year's operations.

The long-range aircraft provided an important distraction to the main task of unloading at McMurdo. There were four of these aircraft; two were Neptunes (a naval patrol aircraft) and two were the naval version of the commercial Skymaster. These four and four smaller aircraft all came south from New Zealand at the end of December, but headwinds defeated the four smaller ones, which returned to New Zealand and never made another attempt. The four larger ones successfully landed on a strip of bay ice at McMurdo, and the crews slept and ate for the most part in their aircraft. They could not live at the temporary base at Hut Point, as communication was bad, nor could they live with the ships on the northern edge. When they wanted to fuel, they just flew up to the temporary strip where the tanker was moored, joined themselves to a hose about 300 yards long, and drank. Of the series of long range flights from McMurdo which may be seen on Figure 4, probably the most remarkable was the one over the South Pole, and the crews reported they had traced the shore lead of the Weddell Sea. Others flying in this region reported the plateau to be as high as 13,000 feet in places. All these flights were done in under a month, and, as soon as they were completed, the aircraft flew back direct to New Zealand. The other aircraft with us were helicopters and Otters. The helicopters were the maids of all work; they were used for placing and supplying survey parties and all sorts of other purposes far too varied to describe. The Otters were intended for longer range reconnaissance flights, and the one assisting the Marie Byrd trail party did invaluable work. At one time it dropped trail flags from the air for about 100 miles—I think they dropped them every fifteen or twenty seconds—and the surface party were able to wheedle in and out of the crevasses following these flags. When this Otter finally crashed, another one was instrumental in finding it, but beyond this the Otters were not used very much.

One thing I would like to mention is fuel: we used no solid fuel, only liquid in the form of aviation petrol, diesel oil and ordinary petrol known to Americans as "mo-gas." The method of landing this was both novel and bold. Some was landed in barrels, but the bulk carried in the larger tanker was pumped ashore through rubber pipes a distance of about 5 miles. The pipe was made up of about five sections, with surge tanks and booster pumps. It was, in fact, an assault fuel system, manned and developed by the United States Marine Corps. Both

at McMurdo Sound and at Little America pre-shaped tanks had been erected ashore for this fuel, and civilian welders put these tanks together. A tank would hold about a third of a million gallons. As well as these, there were neoprene rubber tanks holding about 10,000 gallons each. I think McMurdo Sound had ten of these, and we had also towed down two very small tankers.

That is the brief story of laying down two bases, preparing for two more, and conducting the air operations. While this had been progressing one of the ice-

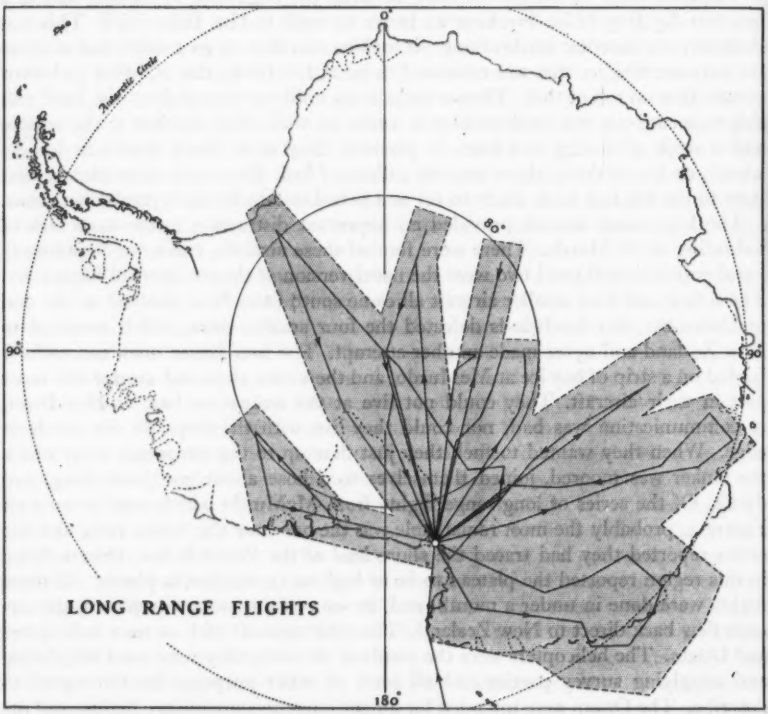
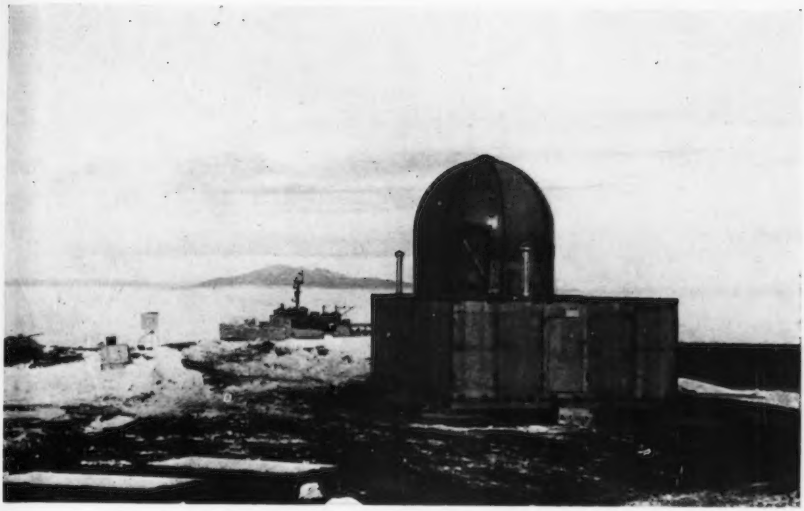
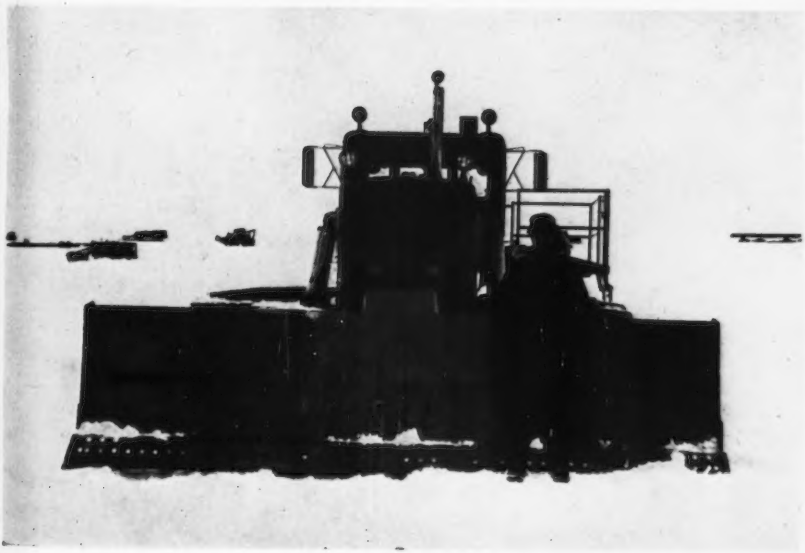


Figure 4

breakers, which had been damaged in the work, had done a survey in the Cape Adare area, and then gone home. All the cargo boats and tankers, as soon as they had unloaded, had gone home as well, and on March 10 *Glacier*, the first ship down there, was the only one left. We said our goodbyes to the ninety men at McMurdo and sailed for home. (See Figure 1.) Rounding Cape Adare, we started our trip around the continent looking for two other sites. The ice was getting a bit thick, even for us, so we forged ahead, mostly at 17 knots, outside the pack ice, only looking in where we thought there might be any reasonable chance of a base. We had a look in Porpoise Bay, a veritable iceberg graveyard. Next, we had a look in at Sabrina Coast—nothing there—worse, if anything, than Porpoise Bay. On the Knox Coast we found some islets called the Balaena Islets where the Russian ship



Rawin tower and meteorological hut at Hut Point



LGP D–8 Tractor

Ob had been eight days previously, and the Australians about two months previous to that. Just south of them are the Windmill Islands, which provide a fairly suitable site for a base and that will probably be the U.S. Knox Coast base next year. Then we went on, round outside the pack ice, past the Russian and Australian bases, and came in to have a quick look at Lützow-Holmbukta to see if there was any suitable site for the Japanese. It was a bit foggy there and we didn't like it, so we went on. We went in to Prinsesse Astrid Kyst and Kronprinsesse Martha Kyst, but saw no really suitable sites. It was now early April, getting late in the season with the winter coming on, and as we did not want to spend the winter in the Antarctic we kept clear of the Weddell Sea. We ploughed on through the fast growing pack ice and at last left it for good; and then, as many have done before, we made our most important landfall—the bright lights of Montevideo.

DISCUSSION

Evening Meeting, 12 November 1956

Before the paper the PRESIDENT (General Sir JAMES MARSHALL-CORNWALL) said: Our lecturer this evening, Lieutenant-Commander Foster, Royal Navy, was in 1955 attached as British observer to the United States Naval Task Force commanded by Rear-Admiral G. F. Dufek which carried out Operation Deepfreeze I. The object of that operation was to establish on the fringe of the Antarctic continent a base or bases, including a very valuable airstrip, for the American scientific teams participating in the International Geophysical Year which is due to commence its operations next July. As Sir Raymond Priestley said in August, in his brilliant Presidential Address to the British Association for the Advancement of Science, the most striking feature of the International Geophysical Year will be the systematic investigation of physical phenomena in and over Antarctica. Forty stations are to be set up by nine different countries in and around Antarctica. The United States of America, as is natural, is taking a predominant part in that combined operation. The United States plan to establish no less than seven bases in and around Antarctica, one of them actually at the geographical South Pole.

The scientific observers who will take part in that joint international enterprise will cover a vast field of research. Apart from oceanography, glaciology and meteorology, they will study aurora and seismic and solar activity, cosmic rays, geomagnetism and even perhaps a little geology. It is a formidable field for exploration. Let us hope that these scientists, after having completed all their complicated computations and having correlated them, will add something to our knowledge of the laws of nature. Actually, what we are about to hear will be confined to the establishment of the scientific bases. The United States of America, as I have indicated, has taken a very great part in that, and we will hear from Commander Foster how the American Navy established the bases on the fringe of the Antarctic continent.

Lieutenant-Commander Foster then read his paper

THE PRESIDENT: I would like to congratulate Commander Foster on his enthralling description of that great enterprise which our American friends carried out in the uninhabited Antarctic. It is rather wonderful to see such a large expenditure of human effort and money in establishing scientific bases in that extremely difficult and forbidding area. It may interest Fellows of our Society to know that in the summer of last year, before he went out on his Antarctic assignment, Admiral Dufek paid a visit to this Society's house and conferred with our staff on problems of Antarctic exploration. During last season's operations, one of his aircraft, as the lecturer has described, took off from the base in McMurdo Sound and carried out a photographic long-range reconnaissance right across the continent to within 100 miles of Dr. Fuchs's base at Shackleton in the Weddell Sea. Admiral Dufek has presented to Dr. Fuchs a

nited States party at the South Pole, 31 October 1956:
ptain W. M. Hawkes (left) and Rear-Admiral Dufek
Planet News Ltd.

complete mosaic of photographs taken by that aircraft, which I think will be of considerable assistance to Dr. Fuchs in planning his adventurous trans-Antarctic crossing. That I call a real instance of international cooperation. I am glad to have with us this evening the Assistant Naval Attaché to the American Embassy—Captain McAlpine.

Captain L. H. McALPINE: I consider it a great honour to be asked to say a few words after Commander Foster's most timely and enlightening lecture on the Antarctic. Antarctic exploration hitherto has often been marred by international rivalry. Operation Deepfreeze is the principal United States contribution to the International Geophysical Year. The future of polar exploration and polar science lies in international cooperation and exchange and it is hoped that the pattern of the International Geophysical Year will be the pattern for further polar work. I would like to briefly mention some of the things being done by the U.S. Navy on this project. During 1955 the U.S. Navy completed preparations for and launched this expedition to establish base facilities for scientists, who will participate in international, worldwide, research in the Antarctic. In preparation for the International Geophysical Year 1957–8, the United States Government, in cooperation with the National Academy of Science and the National Science Foundation, has sponsored an expedition to the South Polar region, preparing facilities for the scientists who are sailing shortly for the Antarctica. During 1955, the Navy's Bureau of Yards and Docks undertook the design and procurement of buildings, equipment and materials for a 60-man land station, a 166-man air base, a 25-man camp at Byrd Land station and a 15-man camp at South Pole station. In early 1956, United States construction battalions, "Seabees" as we call them, started construction on a main base in the vicinity of Little America, and the air operating facility on Ross Island and McMurdo Sound. This October they started building stations in Byrd Land and on the geographic South Pole. Complete facilities for the support of an aircraft squadron will be on Ross Island. These facilities consist of an 8000-foot ice runway, 200 feet wide, complete with radio facilities, an aircraft homing beacon and ground patrol approach unit. The Navy's Operation Deepfreeze, through its role of creating the best possible working conditions for the scientists, is expected to play a significant part in the research activities to be conducted in the South Polar region, and to facilitate the acquisition of valuable scientific knowledge. I should like to wish the Royal Geographical Society continued success in launching future polar expeditions, and in its role of furthering international cooperation in the polar regions.

The PRESIDENT: I thank in your name Commander Foster for his wonderful description tonight, and particularly for those beautiful pictures which he showed us, most of which were taken by himself.

ROME BEYOND THE SOUTHERN EGYPTIAN FRONTIER

L. P. KIRWAN

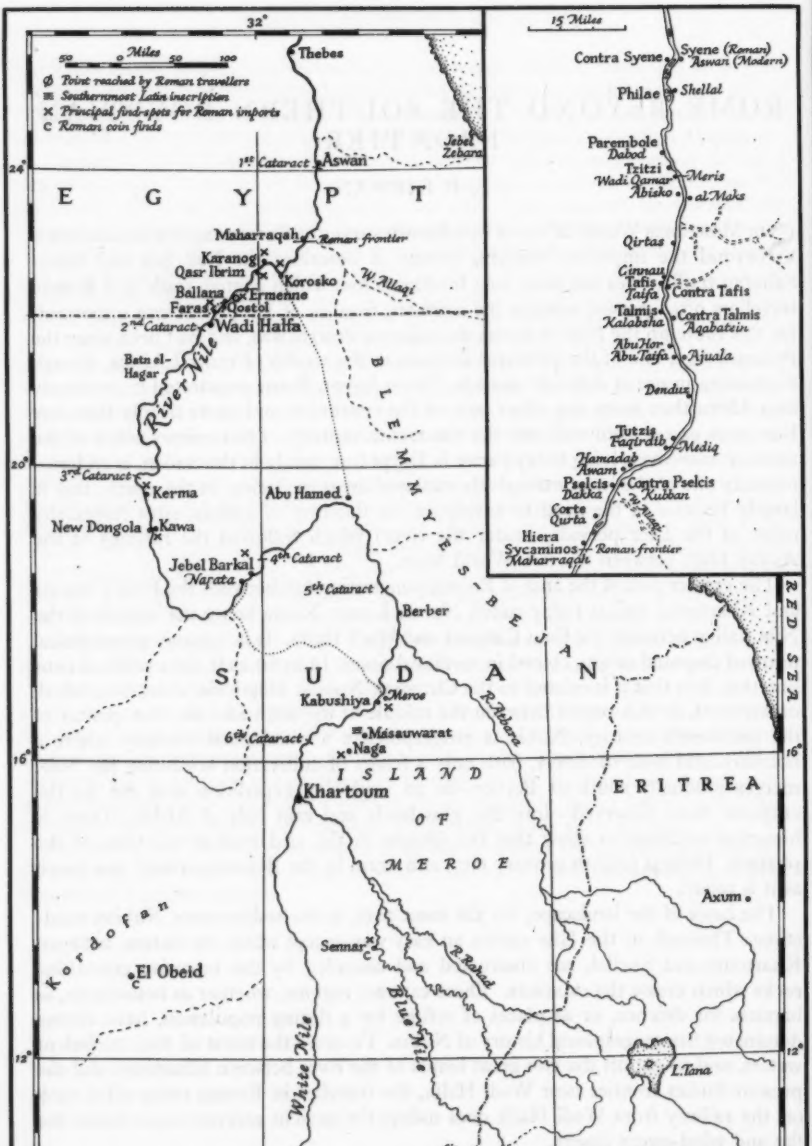
SIR MORTIMER WHEELER'S now well-known survey of Roman exploration and trade beyond the imperial frontiers, though it describes the Red Sea and trans-Saharan traffic, does not cover one frontier across which Roman trade and Roman travellers often passed, namely the southern frontier of Egypt.* It was important, for this route up the Nile or across the adjacent deserts was, and had been since the Pyramid Age, one of the principal avenues to the wealth of central Africa, though fluctuating in use at different periods. From Egypt, Rome penetrated more deeply into Africa than from any other part of the continent, and more deeply than any European power until well into the nineteenth century. The territory south of the frontier, moreover, lying today partly in Egypt but mainly in the Sudan, is archaeologically one of the most extensively explored areas in Africa; in the north, this is largely because of the need to anticipate the flooding of ancient sites (especially those of the later periods, nearer the river) which followed the raisings of the Aswan Dam between the two World Wars.

The greater part of the area of Roman penetration lies between the First Cataract and Khartoum, and is today called Nubia, Lower Nubia being the stretch of the Nile Valley between the First Cataract and Wadi Halfa. It is a purely geographical term, of disputed origin, coined in medieval times. In so far as it has a political connotation, it is that it is related to the Christian Nubian kingdoms which flourished, or survived, in this region between the middle of the sixth and the first quarter of the fourteenth century. Nubia is geographically a transitional territory where a northern arid zone of desert, with only a fringe of cultivation bordering the Nile, merges gradually south of Berber—as an exploring expedition sent out by the emperor Nero observed—into the grasslands and rain belt of Africa. There is historical evidence to show that the climate in the arid zone at the time of the pharaoh Tirhaqa (eighth century B.C.) and again in the Roman period,[1] was much as it is today.

The basis of the landscape, for the most part, is the sedimentary Nubian sandstone. Through it, the Nile carves an easy way except where its waters, between Khartoum and Shellal, are obstructed and cascaded by the intrusive crystalline rocks which create the cataracts. These cataract regions, whether as boundaries, as barriers for defence, or as places of refuge for a fleeing population, have always dominated the geographical history of Nubia. To avoid the worst of their turbulent waters, and to cut off the two great bends of the river between Khartoum and the present Sudan frontier near Wadi Halfa, the traveller in Roman times often took (as the railway from Wadi Halfa does today) the ancient caravan route across the flat and wind-swept desert.

During the Roman Empire, Nubia was both the meeting-place and the battleground of several powers. South of the Egyptian frontier lay the domains of the kingdom of Meroe, from the time of Herodotus "the capital city of the Aethio-

* 'Rome beyond the imperial frontiers,' London, 1954. I use "Roman" as the author does, in the sense of all those who worked in the imperial service. The period dealt with here is from Augustus to Diocletian, first century B.C. to fourth century A.D.


50 0 Miles 50 100
Ø Point reached by Roman travellers
Southernmost Latin inscription
× Principal find-spots for Roman imports
C Roman coin finds
15 Miles
Contra Syene
Syene (Roman)
Aswan (Modern)
Philae
Shellal
Parembole
Dabod
Tzitzi
Wadi Qamar
Meris
Abisko
al Maks
Qirtas
Cinnam
Tafis
Taifa
Contra Tafis
Talmis
Kalabsha
Contra Talmis
Aqabat-zin
Abu Hor
Abu Taifa
Ajuala
Denduz
Tutzis
Faqirdih
Mediq
Hamadab
Amam
Pselcis
Dakka
Contra Pselcis
Kubban
Corte
Qurta
Hiera
Sycaminos
Maharraqah
Roman frontier
Thebes
Jebel Zebara
1st Cataract
Aswan
24°
E G Y P T
Maharraqah
Roman frontier
Karanog
Qasr Ibrim
Korosko
W. Allaqi
Ballana
Ermenne
Faras
Qostol
2nd Cataract
Wadi Halfa
Batn el-Hagar
River Nile
B L E M Y E S
20°
3rd Cataract
Kerma
Abu Hamed
New Dongola
Kawa
Jebel Barkal
Napata
4th Cataract
5th Cataract
Berber
S U D A N
R. Atbara
Kabushiya
Meroe
6th Cataract
Masauwarat
Naga
16°
I S L A N D
O F
M E R O E
Khartoum
ERITREA
Axum
Kordofan
El Obeid
Sennar
R. Rahad
Blue Nile
White Nile
12°
L. Tana
E T H I O P I A
Malakal
R. Sobat
Bahr el Ghazal
Sudd
32°
36°
RED SEA

pians," to use the vague term employed by many of the Graeco-Roman geographers and historians to describe the Nilotic peoples of this region and those of the adjoining desert. Today, the ruins of Meroe and of the miniature pyramids of its royal cemeteries—relics of an African civilization strongly influenced by the traditions and religious beliefs of ancient Egypt—lie near Kabushiya, 130 miles north-east of Khartoum. South-east of Meroe, in the highlands of what is now called Ethiopia, lay the powerful kingdom of Axum. North of Axum, roaming in the deserts east of the Nile, were the Blemmyes, a conglomeration of nomad tribes broadly equivalent to the modern Beja.[2] West of the Nile were numerous tribes, sometimes called "Ethiopians," sometimes "Nubians,"[3] whose wanderings and groupings are hard to disentangle. In the southern part of this western region, in the hill country of Kordofan, there arose in Roman times a great migration of peoples called Noba in the Axumite inscriptions of the fourth century, a massive movement (one of many in African history) northwards and eastwards towards the relatively rich Meroitic cities along the Nile. The attacks of these Noba, and the invasions from Axum in the east, led to the fall of the capital at Meroe towards the middle of the fourth century A.D.[4] The broad interactions of these various powers within this zone of pressure and in relation to the Roman frontier make a rewarding study in the geopolitics of a remote corner of the ancient world.

Culturally and linguistically, Lower Nubia belongs to the northern Sudan rather than to Egypt. In this sense, the boundary between Egypt and the Sudan lies at the First rather than the Second Cataract. At the First Cataract, about 29 B.C., the Roman frontier was established by Cornelius Gallus, the friend of Vergil and the first Prefect of Egypt. It was later moved southwards 70 miles to Hiera Sycaminos (Maharraqah) to include the zone known since Ptolemaic times as the Dodekaschoinos. This stretch of the Nile valley had probably been regarded as Egyptian territory under the Ptolemies, and it had for centuries been a domain and an adjunct of the great temple of Isis at Philae. It was no part of the policy of Augustus to expand the imperial frontiers. But the extension to Maharraqah was sanctified by tradition. From a military point of view, moreover, it gave valuable defence in depth to Egypt proper, it enabled control to be maintained over the river terminus of a strategically important route through the eastern desert from the Wadi Allaqi, and it gave access to the gold mines in the wadi which had been a great source of wealth in Pharaonic times.

As the map (inset) shows, the Roman military stations (and roads) in this frontier zone were almost exclusively west of the Nile, with a few bridgeheads on the eastern bank. The garrisons included at different times both cavalry and camel-borne troops.[5] On the west, they were strategically well placed,* for the Nile was a barrier against the attacks of the marauding Blemmye–Beja tribes of the eastern desert, whose swift raids by desert routes during the Roman period drove deep into Egypt. These Blemmye tribes were a principal, if not the main, factor in forcing the withdrawal to, and consolidation of the frontier at, the First Cataract at the end of the third century.[6]

The *pax Romana* which had been imposed by Cornelius Gallus was suddenly broken during the prefecture of Gaius Petronius (25–21 B.C.) when the Meroites—Sudanese one may call them—taking advantage of a reduction in the Egyptian frontier garrisons to provide troops for Aelius Gallus' campaign in Arabia, fell upon the cities of Syene, Elephantine, and Philae at the First Cataract, overturned

* The only temple on the east bank of this period is at Ajuala, opposite Talmis, tactfully dedicated to the Blemmye god, Mandulis.

the statues of the Emperor and carried off prisoners and booty. The reprisals, which followed immediately, dealt an almost crippling blow at the power of the kingdom of Meroe and carried Roman arms for the first time deep into the Sudan. (See map.)

The story of Petronius' campaign is well known and is described by both Strabo (d. A.D. 24) and Pliny (d. A.D. 79). It need not concern us here except perhaps to lament that a possible Meroitic version of the story is still largely untranslatable[7]. The Meroites, ill-armed, ill-disciplined but far more numerous, were defeated in a series of battles, and by land and by river were driven southwards across the Roman frontier at Maharraqah. Petronius then advanced over the desert and captured Premnis or Primis (Qasr Ibrim), a natural hill fortress controlling the river and desert approaches, dating probably from Ptolemaic times. This the Romans later temporarily occupied as an advance post to the frontier. After the capture of Qasr Ibrim, Strabo and Pliny give differing versions of the route taken by the Romans, though both agree that they penetrated as far south as Napata (Jebel Barkal), an ancient religious centre near the Fourth Cataract. According to Strabo, Petronius, from Qasr Ibrim, struck out across the desert directly to Napata, joining probably the caravan route which runs from Korosko to Abu Hamed. Pliny, on the other hand, states that Petronius, after the capture of Ibrim, continued further up the Nile capturing five other Meroitic cities, the southernmost of which stood "where the River Nile, as it thunders down the precipices, has quite deprived the inhabitants of the power of hearing." No one who has listened to the tumble and rush of the waters in the Second Cataract and southwards in the so-called Batn el-Hagar region (the "Belly of Rocks") can fail to recognize Pliny's description. Of the two versions, Pliny's in this context is to be preferred for south of Qasr Ibrim, but on the west bank of the river, below the Second Cataract, there are at Faras large cemeteries marking the site of perhaps the most important Meroitic city of Lower Nubia. This could scarcely have been allowed to escape the vengeance of the Roman arms.[8]

By the end of the first century B.C., Rome (in a military sense) had thus already penetrated far beyond the southern Egyptian frontier. By the middle of the first century A.D., she had advanced not only more deeply into "the dusky realms of Cephean Meroe" of which Propertius had sung, but even beyond the southern limits of the Meroitic Kingdom, into darkest Africa. Both Pliny and Seneca[9] have told the story of Nero's remarkable expedition, and Seneca—who may well have had a hand in the plans—interviewed the explorers on their return to Rome. The expedition was sent out by Nero in the autumn of the year 61 and consisted of a party of Praetorian soldiers under the command of a tribune and two centurions. Travelling, like Petronius, first up the Nile and then across the eastern desert, they reached Meroe nearly a thousand miles from the frontier. They saw parakeets, and monkeys, and the tracks of rhinoceros and elephant in the neighbourhood. They noted that here the grass was of a "greener and fresher colour" (probably after the rains). They observed too the small, thin trees of the incipient African forest. At Meroe the expedition was provided with a military escort and recommendations to the neighbouring southern tribes beyond the Meroitic kingdom, and they continued their journey up the White Nile until, as they told Seneca on their return to Rome, they "came to immense marshes" where "the plants were so entangled with the waters" that they were impenetrable except, perhaps, to a one-man canoe.[10] This has long been recognized as a description of the *Sudd*, the vast area of floating islands of vegetation south of Malakal, which more than once

have blocked the flow of the Nile. The journey, by any standards, was a sturdy feat of exploration, and from it the expedition brought back a map and much geographical and zoological information. It marked the southernmost known limit of Roman penetration into Africa.

The exact purpose of Nero's expedition is a controversial matter. Was it, as Seneca says, to discover the sources of the Nile, was it in the cause of geography, a subject in which Seneca himself is known to have been much interested? Was it, as Pliny states, a military expedition,* a reconnaissance to collect intelligence in preparation for a campaign against Meroe whose power, as the expedition reported on its return, was evidently on the wane? Or was it, as one modern scholar has suggested,[11] primarily a diplomatic and economic mission, to counteract the threat from Axum, to attach Meroe more closely to Rome, and to revive the ancient trade route down the Nile? This last theory gains support from archaeological discoveries. The power of Rome had, after Petronius, been sufficiently impressed upon the kingdom of Meroe, and the first three centuries A.D. were evidently times of peace, and trade, between Meroe and Rome. The richer Meroitic tombs of this period are accordingly seldom devoid of Roman luxury goods. Inscriptions, moreover, testify to the exchange of diplomatic and other missions.

Ptolemy, it is true, refers in the second century to two Roman military expeditions aimed at the "Aethiopians," [12] but it is far from certain that he refers to subjects, or allies, of the kingdom of Meroe. On the first, Septimius Flaccus (*c.* A.D. 70–100) led his troops across the Sahara, possibly from Lepcis Magna on the north African coast, to Garama, which may be the modern Jerma, near Murzuk, the capital of the Garamantes. Thence he marched for three months into "the midst of the Aethiopians," whom Herodotus (IV, 181–5) also describes as the enemies of the Garamantes. The second expedition, later than that of Septimius Flaccus, was led, so Ptolemy records, by one Julius Maternus. He also journeyed by way of Garama, and joining forces with the Garamantes, then allied to Rome, he marched for four months "against the Aethiopians," to a place called Agysimba "where the rhinoceros foregathers." Agysimba has been tentatively identified with Tibesti, but a journey of four months from Garama would surely, and especially if camels had been used, have taken Maternus beyond Tibesti.[13] Southwards from Tibesti, he might have taken the ancient caravan route, the trans-Saharan route described by Herodotus,[14] which probably ran through the flooded Bodele lowlands to Lake Chad. Alternatively, travelling south-eastwards from Tibesti, he might have reached Darfur or Kordofan.[15]

The peace which followed Petronius' campaign and which was reflected in the welcome given to Nero's expedition in Meroe, is illustrated both by the flow of Roman goods into Nubia, and by the records of Roman travellers who crossed the frontier; some on official missions, some private persons perhaps, like Juvenal's

* The suggestion made by E. G. Turner (*Journal of Roman Studies*, 40 (1950) 58) linking Nero's expedition with Papyrus 40 "della raccolta Milanese" looks improbable. The skirmish there described between Roman cavalry and a combined force of Ethiopians and Trogodytes, probably refers to an engagement between Blemmyes, plus perhaps Meroites, and a Roman cavalry patrol from one of the stations on the Nile, *e.g.* Talmis. Trogodytes probably equals Blemmyes here (*cf.* Eratosthenes in Strabo XVII, 1,786). For cavalry in Nubia, see Lesquier, 'L'armée romaine d'Égypte,' I, 72 ff. Nero's party, which needed a military escort from Meroe, would hardly have taken part in military operations so far off their main route. There is no suggestion in either Pliny or Seneca that they did. Their objectives were Meroe and lands south, and some mention would surely have been made of such an extraordinary eastern diversion. But Turner (*loc. cit.*) disapproves Vogliano's identification of the papyrus with Petronius' campaign.

devotee of exotic oriental cults, who even journeyed "to fetch water from hot Meroe with which to sprinkle the Temple of Isis" in Rome.[16] One Roman envoy posted to Meroe left his name, on his way through Egypt, on the walls of the tomb of the pharaoh Ramses V in the Valley of the Kings.[17] On one of the pyramids of Meroe, there is an inscription in Meroitic hieroglyphs recording a mission bringing gifts from Caesar, "great king of the land of the west." And south of Meroe, far from the Nile, at Masauwarat (the site of a small but imposing Meroitic palace) there is the southernmost Latin inscription known,[18] commemorating a visitor from Rome to this remote spot. The other side of this picture of diplomatic relations is shown in the number of demotic and Meroitic inscriptions found in Lower Nubia with the names of Meroitic ambassadors to Rome.

Only some indication can here be given of trade across the southern frontier, so numerous are the imports from Roman Egypt and elsewhere in the Meroitic cemeteries of this period; especially in those immediately south of the frontier zone. These imports were luxury goods exchanged for African products possibly at an open frontier market at Hiera Sycaminos such as Philosotatus describes early in the third century,[19] or bartered by intrepid traders travelling far up country. Barter must certainly have been the basis of this trade, for only a few Roman coins have been found in Nubia; a coin of Claudius at Meroe, one of Licinius now in the Museum at Khartoum, one of Valens from a tumulus tomb of perhaps fourth century date at Qostol, a coin of Diocletian at El Obeid in Kordofan, and a mid-fourth century coin at Sennar.[20]

From the south came ivory and skins, spices and gum, slaves, and no doubt beasts for the gladiatorial shows in Rome, and pet monkeys for the Roman ladies of fashion. Some gold may have been gleaned from the mines of the Wadi Allaqi in the eastern desert—for Philostratus includes "uncoined gold" among the products brought to the frontier—but no evidence has been found there of Roman occupation, probably because the gold mines, like the famous emerald mines at Jebel Zebara [21] during the later Roman period, were in the hands of the hostile tribes of the eastern desert. From the Roman world came fine pottery and elegant vessels of bronze and glass. And from Egypt itself, one of the great granaries of the Empire, probably corn to supplement the scanty Nubian crops of which Procopius, writing [22] in the sixth century about the time of Diocletian, speaks. Pottery vessels especially characteristic of Romano-Egyptian manufacture, "barbotine" wares and *terra sigillata*, have been found at Karanog, Faras, Meroe, and at Naga further south. More remarkable, because so fragile to transport, are the varied examples of imported glass vessels, tear-bottles and the like, manufactured in the international centre of Alexandria or in subsidiary centres such as Thebes and Koptos. These have been found as far south as Kerma above the Third Cataract, and at Meroe. Some bear a striking resemblance to glass vessels made in Gaul or the Rhineland and are either modelled on Rhenish types, or examples of the vast distances such fragile products travelled in Roman times.[23]

Discoveries of Romano-Egyptian bronze vessels in Meroitic tombs are too numerous to specify, nor could they be properly listed until they, and other imports from the Roman world, found in the cemeteries at Meroe, are fully published. A discovery of such bronze vessels has been reported from as far south as the Sennar Dam, on the Blue Nile.[24] Among other metal imports, a lead bust of an emperor is recorded from Ermenne,[25] a bronze statuette of Zeus from Kawa,[26] between the Third and Fourth Cataract, and a bronze head of Dionysos, of the first century, from Meroe.[27] The fine bronze head of Augustus from Meroe (in the British

Museum) should perhaps not be included since it probably formed part of the booty carried off by the Meroites when they raided the frontier in the first century B.C.

This sketch of Roman penetration into the Sudan and into central Africa, is limited to the period from Augustus to Diocletian and does not cover the even greater flow of Roman imports into Lower Nubia in the fifth and sixth centuries A.D., notably those from the great tumulus tombs at Ballana and Qostol. Nor does it deal with the introduction of ideas, of technical devices from or through the Roman world such as the *saqya* or water-wheel (originating in Mesopotamia), or the wine-press of which the southernmost example, of the second or third century, has been found at Kawa, above the Third Cataract.[28] Both were to have a salutary effect on the meagre economy which geography had imposed on the Nubians of the Nile valley.

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THE GOUGH ISLAND SCIENTIFIC SURVEY

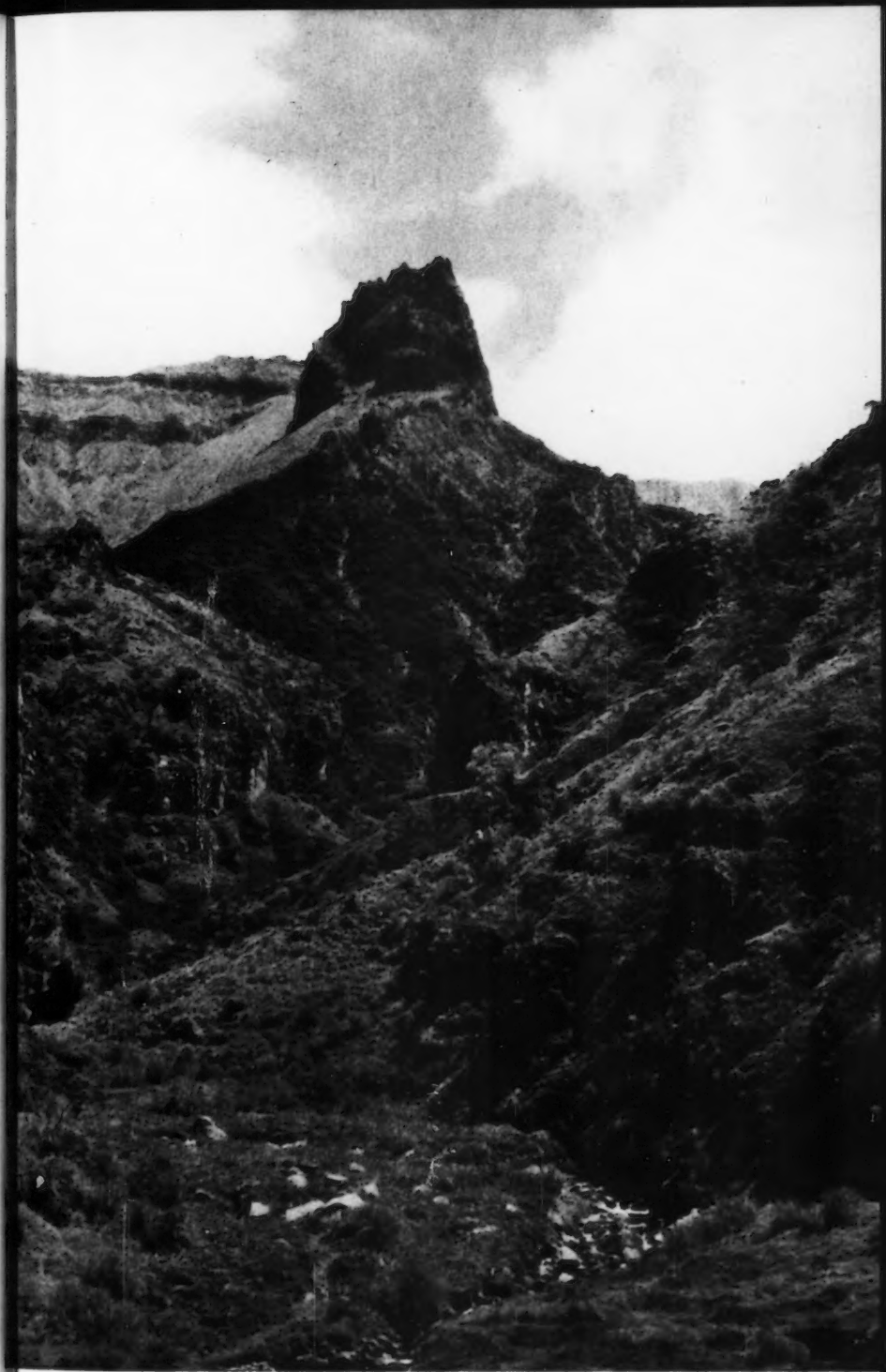
J. B. HEANEY AND M. W. HOLDGATE

GOUGH ISLAND is one of the remotest oceanic islands in the world. Its centre lies at 40° 19′ S. and 9° 56′ W., and it is distant about 1500 miles from the Cape of Good Hope and 1750 from the nearest point of South America. The nearest land is Nightingale Island, in the Tristan da Cunha group, and Tristan itself, 230 miles north-north-west, is the nearest inhabited place. Like Tristan, St. Helena, Ascension, Bouvet, St. Paul's Rocks, and the Azores, Gough is one of the peaks of the Central Atlantic Ridge. This submarine mountain range is one of the longest in the world, extending from Greenland and Iceland to within 1000 miles of the Antarctic continent. Most of the ridge is covered by deep water, and only these few, isolated, volcanic peaks rise to the surface. Gough Island only rises 3000 feet above sea level, but its total height from base to crest exceeds 10,000 feet. It is about 8 miles long and 4 wide, its terrain is rugged, and its coasts are girdled by high cliffs.

Like its neighbours, Tristan da Cunha and St. Helena, Gough Island was discovered by Portuguese navigators during the early years of the sixteenth century. It was named Gonçalo Alvarez, after the captain of Vasco da Gama's flagship on his epic voyage to the east, and under this name it was marked with reasonable accuracy on the charts of the South Atlantic during the following 250 years. Then, in 1731, Captain Gough of the British ship *Richmond* reported the discovery of a new island, which he placed 400 miles to the east of Gonçalo Alvarez. Fifty years later cartographers realized that the two islands were the same and, despite the priority of the Portuguese discovery, and the greater accuracy of the position given by them, "Gough's Island" was the name adopted.

The first people to show more than a passing interest in Gough Island were sealers. During the eighteenth and nineteenth centuries many ships from American and European ports sailed for the south, and the teeming fur-seal populations of the sub-Antarctic islands were virtually exterminated by indiscriminate slaughter. During this period the only other visitors to Gough Island were warships, which cruised round the coasts for a few days, made running surveys, and determined the island's position. But scientific interest was stimulated when George Comer, leader of a sealing party, returned with notes and bird specimens in 1889. Among his discoveries was a flightless landrail (named *Porphyriornis comeri*) which proved to be confined to the island. In 1904 the Scottish National Antarctic Expedition in the *Scotia* spent three days at Gough and, after considerable difficulties, succeeded in landing a shore party for a few hours. This party collected rocks, plants, birds, and a few insects and showed that the island had a second peculiar species of bird (a small bunting) in addition to the flightless rail.

Further collections were made by a party from the *Quest* in 1922. These men spent three days ashore and climbed one of the principal peaks of the island. They named this Mount Rowett, after the patron of their expedition, and estimated its height (by aneroid) to be 2915 feet. Later visits, by the *William Scoresby* in 1927 and by a Norwegian party in 1934, extended the list of recorded plants and animals. These collections, made by men who had landed under difficult conditions in an



The Hag's Tooth, from Base Camp, rising above the broken, forested slopes of The Glen

Deep Glen, a typical Gough valley

Base Camp: now Gonçalo Alvarez weather station

inclement season, at least indicated that Gough Island deserved more thorough scientific study. In 1937 Erling Christophersen of Oslo formed an expedition for this purpose, but never got nearer than the Tristan group. In 1938 a party from the British warship H.M.S. *Milford* raised the flag and proclaimed Gough Island a dependency of St. Helena. In 1955 our own expedition began a six-months' stay during which a fairly complete scientific survey of the island was made.

Part of the attraction which Gough Island possessed is common to all little-explored country. The maps of the island, all of them based on running surveys from ships, did not show even the coast-line accurately and made no attempt to represent the hills and valleys of the interior. But the island is a very tiny speck on the earth's surface, and nobody would form an expedition to explore an area 8 miles by 4 unless it had especially interesting features. Our expedition was justified on scientific grounds. A study of the island's rocks might throw light on whether the Central Atlantic Ridge had "continental" affinities, and on possible former continuity of land in the southern hemisphere. The plants and animals were of interest for two main reasons. Firstly, it is very difficult for any species to cross over 1500 miles of ocean and hit so tiny a target as an island 8 miles by 4. Yet, since the island arose by volcanic eruptions in mid-ocean, all those species now present there must have made this journey. A study of these animals and plants might indicate the methods by which they had arrived; for example, a preponderance of light seeds or spores might suggest that transport by wind had been the chief method of plant immigration. A remote island is a natural testing ground for different methods of biological distribution.

Secondly, after their arrival at such an island, animals and plants are cut off from interbreeding with stocks in the outside world. Over the years, the two stocks tend to diverge, and the island to acquire peculiar species which are found nowhere else in the world. A study of such "endemic" species is of great interest, and we already knew that there were many of them on Gough.

Finally, there were two economic projects with which the expedition could assist. A census of the fur-seal population, which was known to be re-establishing itself, would indicate whether a controlled harvest of skins could be taken once again. A weather station, whose bulletins would be radioed to South Africa, would determine the usefulness of Gough Island in meteorological studies. If this pilot station proved successful it might be replaced by a permanent base.

For all these reasons Gough Island seemed an excellent objective for a small private expedition. The idea was given to J. B. Heaney by Dr. B. B. Roberts of the Scott Polar Research Institute in Cambridge in June 1954 and the planning of the Gough Island Scientific Survey began soon afterwards. Heaney found little difficulty in selecting personnel and his final list was: J. B. Heaney (24) organizer (first) leader, surveyor (did not take part in initial field work); R. J. H. Chambers (23) (second) leader, surveyor (led during journey and landing on Gough); M. W. Holdgate (24) (third) leader, zoologist (led during initial field work, latterly with Heaney); J. P. Hall (32) cine-photographer and medical officer; R. W. LeMaitre (21) geologist; P. J. Mullock (22) radio operator; M. K. Swales (24) zoologist; J. J. van der Merwe (29) meteorologist (seconded by South African Weather Bureau); N. M. Wace (25) botanist. Except for van der Merwe, all these members were graduates of British universities.

The expedition encountered the usual financial difficulties, but we are most grateful to all those Societies, Colleges, firms and individuals whose confidence in the venture at last made it possible. The first supporters were the Scott Polar

Research Institute and the Royal Geographical Society. His Royal Highness the Duke of Edinburgh showed great interest and made a substantial contribution to the funds. Among the many other supporters were the Mount Everest Foundation and the Royal Meteorological Society. Many firms made generous gifts of food and equipment, the scale of their assistance being indicated by the fact that the total expenditure on food for eight men for six months was only £52 10*s*. Had these supplies been bought at normal rates the cost would have been about £800.

Although Gough Island is classified as sub-Antarctic, the experiences of earlier visitors had shown that it had a typically oceanic climate with moderate temperatures and a high rainfall. Strong winds were said to be frequent, and the valley in which most visitors had lived was said to funnel the gusts. In these conditions tents would be most unsatisfactory as the sole living accommodation, especially if careful scientific work was to be done. It was decided that a sectional wooden hut must be taken, as a base, though tents would be used in minor camps. Meteorological equipment was loaned by the South African Weather Bureau, scientific collecting gear by the British Museum (Natural History), and surveying instruments by the Directorate of Colonial Surveys, the Royal Geographical Society, and the South African Trigonometrical Survey Office. The Royal Navy agreed to take the party from Simonstown to Tristan da Cunha in the frigate H.M.S. *Magpie*, which would be paying a routine visit to that island. The Union-Castle Mail Steamship Company granted special terms for passages to the Cape, and the Tristan da Cunha Development Company promised to transport us across the last 230 miles from Tristan to Gough.

Sailing dates were fixed for September 1955, and by that time the financial situation was satisfactory. But in July J. B. Heaney was advised by his doctors that it would be unwise for him to take part in the field work. He handed over the leadership to R. J. H. Chambers, who was given a course by the School of Military Survey. Heaney's place in the party was taken by J. P. Hall, who came as cinephotographer and medical officer, and a filming programme was financed by an advance made on a contract with Associated Rediffusion Ltd.

The expedition landed on Tristan da Cunha on 1 October 1955 under ideal weather conditions. During the following six weeks N. M. Wace and M. W. Holdgate studied the island's vegetation and secured samples of peat from a mountain bog appropriately named Soggy Plain. It is hoped that these will throw light on the history of the island's vegetation and climate. M. K. Swales studied the birds and agriculture, and J. P. Hall, R. W. LeMaitre and P. J. Mullock obtained photographic records of island life and tape recordings of the islanders' speech and songs. The pleasant personalities, physical strength, and skilled oarsmanship of the islanders made a great impression, and two of the older and more experienced men were asked to accompany the expedition to Gough. Arthur Rogers (55) and John Lavarello (60) were employed for an initial period of about six weeks. After their return to Tristan their places were taken by Harold Green (21) and Ernest Repetto (29).

On November 12 the expedition embarked in the M.V. *Tristania*, one of the two vessels which spend the summer months fishing for crawfish in the shallow waters around the islands of the Tristan group and Gough. On November 13 a landing was made on Gough Island, in the mouth of The Glen, the largest of a series of valleys running down to the east coast. This place was chosen because earlier visitors (and the present-day fishermen) had found that it was the most sheltered

landing place; it had a good beach, some level ground suitable as a site for Base Camp, and gave access to the interior of the island. Thanks to the good weather conditions, no difficulty was experienced in landing the 15 tons of stores on the steep shingle beach. Thirteen-foot wooden fishing dinghies, each handled by one fisherman, were used for this. They proved very manoeuverable, and small enough to be easily hauled up clear of the surf and launched quickly during a "smooth time," or lull in the waves. Gough's beaches had an evil reputation, and we had decided in England that the weight of crates must be kept below 70 lbs. where possible. This figure was considered the maximum which a fit man could handle alone under difficult conditions. The fuel (diesel oil and paraffin) was taken in 5-gallon Robbiecans which were also easy to handle. All crates containing perishable goods were waterproofed with heat-sealed polythene linings. Large crates, such as those containing the generator and radio equipment, weighed up to 5 cwt. and might have proved impossible to land under bad conditions. The hut sections, which were 7 feet square, would have been equally awkward. As it was, however, these cumbersome packages came ashore without difficulty.

The site for Base Camp, on level grassland 20 feet above the sea and 10 feet above the highest visible storm mark, was soon selected. After we had stripped off the turf we found many relics of earlier occupants, including the foundations of a hut known to have been built during an abortive diamond-prospecting visit in 1919. The building of the hut was lent added urgency by a suspected spinal injury sustained by R. J. H. Chambers, the expedition's leader, within a few minutes of landing. Four days later, however, an opportunity arose for his evacuation to Tristan, and he soon afterwards went to Cape Town for specialist diagnosis and treatment. Despite a rapid recovery it was considered inadvisable for him to return to Gough, where his place as leader was taken by M. W. Holdgate.

The sectional wooden hut, made by T. Bath & Co. of London, proved excellent for our purposes. The living room, 18 feet by 12 feet, was fitted with wooden shelf-bunks in two tiers, and had a long table under the windows where scientific work could be done. The kitchen was 12 feet square, and equipped with a Valor twin-burner paraffin stove, supplemented by pressure stoves. At the west end of the hut was a radio room and a photographic darkroom, each 6 feet square. The walls were of creosoted weather-boarding, and the roof covered with bituminous felt. The hut was set end-on to the strong gusts expected to blow down the valley, and additional security was given by steel hawsers passed over the roof and shackled into concrete blocks.

The meteorological instruments were set up close to the hut, on the banks of the stream which flowed down the centre of The Glen. All the equipment was standard. The radio equipment, on which the efficiency of the weather station depended, consisted of a Pye PTC 60 watt HF station as main transmitter and receiver. This unit is crystal-controlled on four channels, and was fitted with crystals for the frequencies specified by Cape Town radio, to which the bulletins were sent. The second transmitter, designed for amateur wave-bands, but in fact used a great deal for commercial work, was a Panda PRV 120. Both these transmitters would work for radio-telephony, and were used for regular discussions with Tristan da Cunha and with the two fishing ships. The second receiver, used in preference to the Pye because it was not crystal controlled and could therefore be used for broadcast reception, was an Eddystone 680 X. All this equipment was powered by a generator run by a 2-h.p. Petter Ava diesel engine, housed in a shed near the beach. This

generator also provided current for the hut lighting. A small pedal generator, which could be used to charge 12-volt heavy duty accumulators used in conjunction with an army 62 set (transmitter-receiver), was taken as a standby.

Members of the expedition took it in turns to cook and carry out essential chores at base, for a whole day at a time. Most foodstuffs were tinned or dehydrated, but there was still a good variety. Fish and crawfish were easy to catch from a dinghy, and excellent in flavour. The birds of the island, notably the three species of albatross, are very good eating, but were rarely taken. A young Wandering Albatross, however, provided the Christmas dinner. We had seal meat, of which the liver and shoulder muscle proved the favourite cuts, when an animal was taken for scientific purposes. These extra sources of food added further variety to our diet. Unfortunately, attempts to grow vegetables were nearly all unsuccessful; the only edible plants growing on the island are a rather poor quality of wild potato, a stringy and tough endemic wild celery, and a small crowberry. Drinking water was taken from a small side stream passing the hut, or occasionally from the main Glen stream. Both these sources proved, on subsequent analysis, to be highly polluted, but we suffered no ailments which could be traced to the water supply!

The day's plans were discussed over the breakfast table, and while each member was completely free to organize his own special programme of work, a certain amount of coordination was necessary. Solitary excursions on the mountains were discouraged, and on the sea were out of the question, so that parties were generally formed to go to particular objectives the locations of which were usually decided by the weather. All parties leaving the base wrote a summary of their intended movements on a sheet of paper pinned in the kitchen; this would have assisted a search party had one ever become necessary. Dinghy parties always carried the army 62 set, and kept regular "skeds" with base, reporting their progress. They were also able to make contact with the fishing ships, which were usually to be found in the lee of the island. Before going to Gough we had been advised not to use boats around such a remote and stormy coast, but there were several reasons why this advice was over-cautious. Firstly, the skill and experience of the Tristan islanders made accidents unlikely. Secondly, we were able to keep in touch with base and the ships by wireless, and could have called for aid if necessary. Thirdly, even if we were unable to return to base against a freshening wind we could take refuge aboard one of the ships, or ashore. Indeed, one of our chief regrets was that we had no outboard motor for the dinghy, which would have increased its range and usefulness.

The exploration of the island was begun about ten days after the landing. The first party ascended The Glen, following the stream as far as possible since it provides the easiest route through the dense forest that covers the low ground. About half a mile from the sea the valley divides, one branch passing on either side of the bold rock peak known as the Hag's Tooth. This is a trachytic plug filling an old volcanic vent; it rises from forested slopes as a tower of rock with sheer sides and a jagged crest. Eventually the party was forced to leave the stream and struggle up through the forest to the open grassy slopes around the base of the Hag's Tooth. The forest zone extends from sea level up to about 1000 feet. The dominant species, the "island tree" (*Phylica arborea*) generally straggles along the ground, its branches intertwining. Between the trees, small gaps are filled with tree ferns (*Blechnum tabulare*) which, although they are only a few feet high, are equally awkward to walk through. The canopy of branches and fern fronds hides the inequalities of the ground. As a result of all these features a quarter of a mile in

an hour was reckoned a fast pace through forest, and when routes came into frequent use they were improved by the cutting of paths.

The party from the *Quest* had ascended The Glen in 1922, and had given a fairly accurate description of the valley and its flanking ridges. But when our first exploring party reached the crest of the ridge behind the Hag's Tooth, three-quarters of the view was over terrain about which nothing was known. Although fresh details of topography were revealed on many later journeys, this, therefore, seems an appropriate point at which to give a general description of the structure of Gough Island. Reference to the map at the end of this paper will help in making this description clear.

The deep dissection of the Gough Island landscape, which is in such marked contrast to the regular conical form of Tristan da Cunha, seems good evidence that volcanic activity ceased a very long time ago. Many millions of years of erosion must have been necessary to bring the island to its present state. The centre of the island is a plateau about 2000 feet above the sea, largely formed from horizontal, basaltic lava flows. Tarn Moss, immediately to the north of Mount Rowett, is the largest part of this plateau. The plateau forms a pedestal, in some ways reminiscent of the Base on Tristan, on which the highest peaks stand. Edinburgh Peak (2986 feet), the summit of the island, rises in gentle slopes immediately to the west of Tarn Moss, and like it is composed of basaltic lavas. Further to the north-west, the second summit, Expedition Peak, also rises in gentle slopes. But the surface of the plateau here is not so uniform, and is not composed of basaltic flows except in its westernmost projection at Sea-hen Crag. Around Expedition Peak, the plateau (and the peak itself) is made up of dome-shaped masses of trachyte which may have been intruded as laccoliths. Trachyte flows also form all the western side of the island, where the plateau rolls down in a series of rounded hills and shallow valleys to the tops of the sea cliffs.

The distinction between the western half of the island, which is composed of trachytic rock, and the eastern side which is built up from an upper and a lower series of basalts, is reflected in the topography. For, while the western side contains no large valleys—the plateau extending to the brink of the 1500-foot cliffs—on the east and north, a series of eight deep glens cut back into the central upland. The ridges between them are narrow and craggy and, since they attain a height almost identical with that of the plateau, seem certain to be residual masses isolated by dissection. Most of the eastern valleys end in sheer cliffs (The Glen, the largest example, being exceptional). This might indicate that coastal erosion has, in the past, been more rapid than sub-aerial processes. But many of the streams draining the valleys are now cutting gorges in a manner which suggests recent rejuvenation of the stream systems. Patches of what may be a raised beach also lie to the south of The Glen. There would thus appear to be clear evidence of a recent uplift of the order of 200–300 feet, while the more gentle contours and extensive plateaus above 2000 feet may indicate a former uplift of much greater magnitude. It is hoped to discuss this in more detail elsewhere. The volcanic origin of Gough Island is just as evident in the details of its topography as it is on a larger scale. Besides the Hag's Tooth there are three other intrusive stocks, two of which form bold peaks. Dykes are an impressive feature of the main valleys, and the largest of them all, in The Glen, stands 70 to 100 feet clear of the slopes, is 15 feet thick, and may be traced across country for a mile. All these typical features of the eastern valleys are evident in the photograph of Deep Glen (facing p. 21). The skyline in this picture is the edge of the central plateau, and a trachyte plug rises in the valley

head. The forest line, at about 1000 feet is clearly visible. The abrupt termination of the valley in sea cliffs, and the deep gorge, which suggests recent uplift, are both typical of the island's valleys.

This account of the island's topography demonstrates what was clear to the first exploring party when they stood on the summit of Mount Rowett: that the bulk of the expedition's work must lie away from base. For the terrain was even more complex, and the maps less accurate, than we had expected, and most of the interesting country lay towards the northern end of the island. Two camps were therefore established, one in the head of Camp Glen, at the northern end of the plateau, and one in Gony Dale in the south. These both lay high, the former at 2000 and the latter at 1400 feet. Using them, it was possible to take advantage of short spells of fine weather, which often only lasted for a few hours. The tents used were of a standard Meade pattern, rectangular in plan, modified by the addition of a bell-end designed by R. J. H. Chambers. The floor area, excluding the bell, was 7 feet 6 inches by 5 feet, the ground sheet was sewn in, and the whole proved tolerably weatherproof. These tents were strong and well guyed, and were left unattended for periods of up to a fortnight without damage. Supplies were carried up by the Tristan islanders from time to time, and parties in camp kept in touch with news from base by using an MCR 1 midget wireless receiver. In this way weather forecasts and incoming messages could be given each night to parties on the mountains.

During most of our time on the island the weather was governed by a succession of depressions, moving over the island on an eastward course. A thin film of cirrus heralded the advent of a warm front, and when medium cloud thickened, giving a "watery sky," it was a sign that rain was imminent. The rain associated with a warm front lasted from twelve to thirty-six hours, and during this period the camps were usually enveloped in low cloud. All that one could do was to lie in one's sleeping bag —sleeping, eating and reading or writing in turns and listening to the rain drumming on the canvas. It was a cramped existence and, since the tent groundsheets were far from waterproof, it tended to be a wet one also. Fortunately, we had inflatable rubber air-mattresses which kept sleeping bags and occupants clear of the puddles. The only "entertainment," if such be its right title, was provided by the mice. These were very common over the whole island, and once they discovered that a small tent on the mountains contained a limitless amount of food, they became frequent visitors. Lying awake at night, we would hear a patter of feet across the floor, echoing more loudly when the mouse climbed onto an air bed, and culminating in a grunt or a wild blow when it trespassed on a companion's face. Trapping became a necessity, and at High Camp (the northern and higher camp) fifteen were caught in one evening using an ordinary break-back trap. At Base Camp an elaborate water trap designed by J. P. Hall accounted for over 300 in under 10 days. The rain of a warm front would be followed by showers, accompanied by a wind veering towards the west. A cold front was generally accompanied by strong winds and heavy showers, and then, as the depression passed, the wind would settle in the south-west and we would have from six to thirty-six hours of fine weather.

When R. J. H. Chambers was carried on board *Tristania* four days after the landing, he left behind a comprehensive set of survey instruments but nobody trained in their use. But the need for a survey was so great that it was unthinkable that this programme should be given up. Holdgate, Mullock and LeMaitre therefore began to plan a triangulation scheme. During the fine month of

December a start was made on the observations and cairns were erected on many peaks. But the inexperience of the team, and bad weather during January, made the prospect of making a complete map representing all the intricacies of the terrain seem remote. Then, in early February, J. B. Heaney, the original leader and surveyor of the expedition, was passed fit and came out to join the party. He and Holdgate became joint leaders, and also combined as a team for the survey. Under Heaney's guidance the map was completed during the following ten weeks, aided by a remarkable improvement in the weather. The survey was done at 1/30,000, and the map has been fair-drawn and printed by the Society at a scale of 1/40,000. It is included at the end of this paper.

The triangulation scheme, involving twenty-five theodolite stations, included all the chief peaks and a number of coastal features. A baseline, 1860 feet long, was measured on an even, boggy, ridge crest over 2000 feet above the sea. This work, like most of the survey on Gough, was hampered by the wet ground and unpredictable weather. Once the triangulation network had been observed it was plotted on the plane-table sheet, to provide control for the detail survey. At any single plane-table station, rays were drawn to many prominent features, whose distances were measured, using an 80-centimetre rangefinder. The angles of elevation of these points were obtained with a clinometer, and the true horizontal distances and heights were then calculated by using a slide-rule. A dense control of spot heights was thus built up and the contours, at intervals of 250 feet, were interpolated from these in the field. Only a small proportion of these spot heights have been retained on the printed map. The map was orientated by an azimuth determined from the sun for the line from the Archway Rock to the Hag's Tooth. The position of a prominent boulder on the crest of the Archway Rock was fixed by position line observations to sixteen stars. The position obtained, 40° 19′ 19″ S., 09° 53′ 42″ W., differs by over a minute in both latitude and longitude from that given on Admiralty Chart No. 1769, but is in fair agreement with the results obtained by Commander F. A. Worsley, D.S.O., R.N.R., of the *Quest*. Most of the coast, except for the western shores which are buffeted by an almost perpetual swell, was surveyed using a 13-foot dinghy. Stations were selected either on headlands or on off-lying rocks which were high enough to allow the plane-table to be set up clear of the spray and which gave a good view of fixed points in the interior. The Tristan islanders proved expert at backing the dinghy in carefully during a "smooth time," so that the survey party could leap out onto the seaweed-covered rocks.

The place-names used on the map are derived from three sources. Firstly, names marked on Admiralty Chart No. 1769 were regarded as official and were accepted, except in one case of grave ambiguity (High Peak). Secondly, names given by the officers of the two fishing ships, *Tristania* and *Frances Repetto*, and in local use, were generally accepted. These names refer almost exclusively to coastal features. The third group of names was given by the expedition. These refer chiefly to features in the interior of the island and on the western coast. The highest mountain was named Edinburgh Peak in partial acknowledgement of the great encouragement which we had received from His Royal Highness the Duke of Edinburgh. This name is rendered especially fitting by the Duke's visit to Gough Island in January 1957. The rest of the names which it was proposed to include on the final map were submitted to the Colonial Office, and their approval has been obtained. For the present, the names printed on the map at the end of this paper are to be regarded as official, but it must be recognized that others may come into use on the island itself, and among the islanders who fish around its coasts. It will

probably be necessary to revise at a later date, the names printed on the charts in favour of these local traditions. Otherwise the situation may well come to resemble that at Tristan, where hardly a single name on the Admiralty Chart is recognized on the island.

Regular bulletins were transmitted to Cape Town Radio at 0600 G.M.T. and 1200 G.M.T. daily from 20 November 1955 until the end of the expedition. The weather at base proved to be relatively warm and wet. During the five months between December and April the mean monthly temperatures were 15·2, 14·6, 15·4, 13·9 and 13·7° C. respectively. The highest maximum during this period was 23·7° C. (on February 17), and the lowest minimum 5·5° C. (January 25). The rainfall totals were 197·7, 304·5, 152·2, 101·1 and 261·9 millimetres, while the mean daily sunshine figures were 5·4, 5·5, 4·7, 2·2 and 1·8 hours respectively. The sunshine figure for April was reduced by the fact that the sun did not clear the crest of the steep ridge to the north of The Glen; the valley is so narrow and deep that it proved impossible to site the recorder to give unobstructed exposure for the whole day. The succession of warm and cold front systems which characterized the oceanic climate have already been mentioned. The barrier of the island, lying athwart the prevailing winds, caused disturbances in the air flow, and various standing wave cloud systems were observed and photographed.

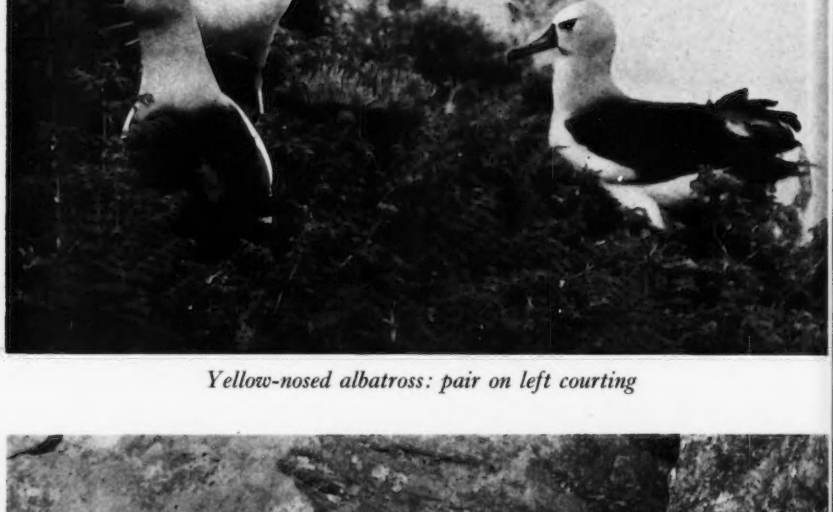
R. W. LeMaitre was able to distinguish four main phases in the island's geological history. In the first stage a cone of basaltic lavas, with local pockets of tuff, was built up, and this was later invaded by a dyke swarm which radiates from near the present centre of the island. Then, after a period of quiescence, further activity commenced with a great explosion in which the western half of the cone was blown away. Trachyte lavas welled up and poured over the western rim. As a result, the new cone had an eastern half composed largely of the original basalts, and a western half of the newer trachytes, and this division is evident today. The next phase was the deposition of an upper series of basaltic flows forming the plateau lavas and the beds which are now exposed in the cappings of South Peak, Mount Rowett, Edinburgh Peak and Nigel's Cap. Last of all came the intrusion of the trachyte laccoliths now exposed in Expedition Peak and the barren dome-shaped hills around it. The stocks such as the Hag's Tooth may be feeders for similar laccoliths whose mushroom-shaped tops have been removed by erosion. It is impossible to date the rocks of Gough Island at present, but LeMaitre hopes to be able to do this after the radioactive potassium: argon ratios in trachyte samples have been studied. In his future work LeMaitre hopes to undertake a detailed petrographical study of the island's rocks, and of their relationships with those of other oceanic islands.

The vegetation of the island makes an immediate impression on the visitor. From the sea the whole landscape seems green, for grass tussocks and ferns cling even to the nearly vertical cliffs. Tussock grasses are generally the chief components of the cliff-face and cliff-top vegetation. Away from the sea, the low-lands up to the 1000-foot contour are covered by dense forest of *Phylica arborea*, associated with *Blechnum tabulare* and other ferns. As we have already mentioned, this forest is so dense as to make progress through it is always slow and frequently blasphemous! Above 1000 feet the tree fern forms a transition scrub zone, soon giving way to "grassland" which varies in its luxuriance with altitude and exposure. The upland plateaus are crusted with reddish and yellow-green *Sphagnum* mosses above the deep peats. The rolling uplands, with this familiar vegetation, look very like parts of the Scottish Highlands or the Pennines. Some of the trachyte domes

Surveying on the Hag's Tooth

The summit of Gough Island: Edinburgh Peak (2986 feet): from North Rowett

Yellow-nosed albatross: pair on left courting



Young Kerguelen fur-seal

are remarkable in being almost bare of vegetation, perhaps owing to the chemical composition of the rock.

Besides describing the vegetation, N. M. Wace made large collections of plants, which included many species new to the island. He also obtained peat samples from the mountain bog named Albatross Plain. From a study of the pollen preserved in these it is hoped to discover something of the vegetational history and past climates of the island, while estimates of the radioactive carbon in some samples will give absolute dates for different horizons in the bog.

The invertebrate fauna of the island proved to contain very few species, and M. W. Holdgate considers that the total list from the sixty collecting stations which he examined will not exceed 150 species. The vertebrate fauna, if fewer in its number of species, is far more spectacular. The only land mammal is a mouse (*Mus musculus*), probably introduced by sealers. Two species of seal inhabit the island's beaches. The larger of these, the sea-elephant (*Mirounga leonina*) is not numerous—the total population is about 300—but the other species, the fur-seal (*Arctocephalus gazella*), numbers about 13,000. M. K. Swales, assisted by other members of the expedition, made a census of the fur-seals, visiting and counting the populations on all the beaches. Most of the breeding beaches lie on the west coast and are difficult of access, since they lie at the foot of high cliffs and are washed by an almost perpetual swell. The species of seal, *A. gazella*, is one of the rarer southern fur-seals, and over half the world population probably breeds on Gough. After careful consideration, Swales decided that a small annual harvest of skins of young males may be taken without endangering the stock. A licence has been issued to the Tristan da Cunha Development Company to take up to 500 two- and three-year-old males in the season 1956–7.

Swales also made extensive observations on the birds of Gough Island, and especially of the two endemic species, the bunting and the flightless landrail. Unfortunately we arrived too late to see the breeding of the bunting, while the rail was so secretive in its behaviour that it succeeded in bringing off a brood unobserved, right under our noses. But juveniles of these species were seen in many stages of development, and Swales was able to show that the bunting, which had once been thought to be two species, was in fact one only but had five well-marked plumage stages.

Some observations were also made on the three species of albatross breeding on the island. One of these, the Tristan sub-species of the Wandering Albatross (*Diomedea exulans dabbenena*) is now practically confined in its breeding distribution to Gough. The Southern Skua (*Catharacta skua*) and the Rockhopper Penguin (*Eudyptes cristatus*) were also studied in some detail. A very great number of night-flying petrels and shearwaters, whose burrows honeycomb the hillsides, were caught by using a bright light. This dazzles the birds, which lose all sense of direction, spiral round overhead and eventually come to the ground. Over a thousand of these birds were caught, weighed, measured and then released. The Greater Shearwater (*Puffinus gravis*) was found to breed on the island in large numbers, as was the Kerguelen Petrel (*Pterodroma brevirostris*). But these were far from being the most numerous species, for the populations of the Broad-billed Prion (*Pachyptila vittata*) and the Soft-plumaged Petrel (*Pterodroma mollis*) were both estimated at several million pairs. This abundant bird life was one of the most striking features of the island, seen at its best when the light trap was in use. The hundreds of white bodies, wheeling overhead, looked like a snowstorm around a street lamp.

J. P. Hall exposed about 22,000 feet of colour cine film, rather more than half of it on Gough Island. He concentrated on filming the wild life of the island, and obtained some very successful shots of seals and sea-elephants and of rails, buntings and other birds. Quite apart from their popular interest, many sequences, such as those of the courtship display in the Wandering Albatross, have great scientific value. M. K. Swales and P. J. Mullock obtained a comprehensive series of recordings of the calls of the island birds and seals. Two tape-recorders were in use, one being small and portable for use in the field, and the other a larger instrument which was kept at Base Camp. The recordings are housed in the Records Library of the B.B.C.

The scientific programmes were nearing completion by the end of April 1956, and the expedition was relieved by the South African frigate *Transvaal* on May 13. The South African Weather Bureau had found the bulletins from Gough of such value that they had obtained permission to continue the station, at least until the end of the International Geophysical Year. They purchased the hut and other installations, and J. J. van der Merwe remained behind as officer-in-charge of the new station. He was also sworn in as Magistrate, and took over the duties of Postmaster from Mullock. The expedition landed in England on June 11, and the distribution of specimens and working up of results began soon afterwards. The biological specimens will eventually be deposited in the British Museum (Natural History). Accounts of the detailed aspects of our work will be published in the appropriate journals. The time spent in amassing the results, like that in preparations, will certainly far exceed the time occupied in the field.

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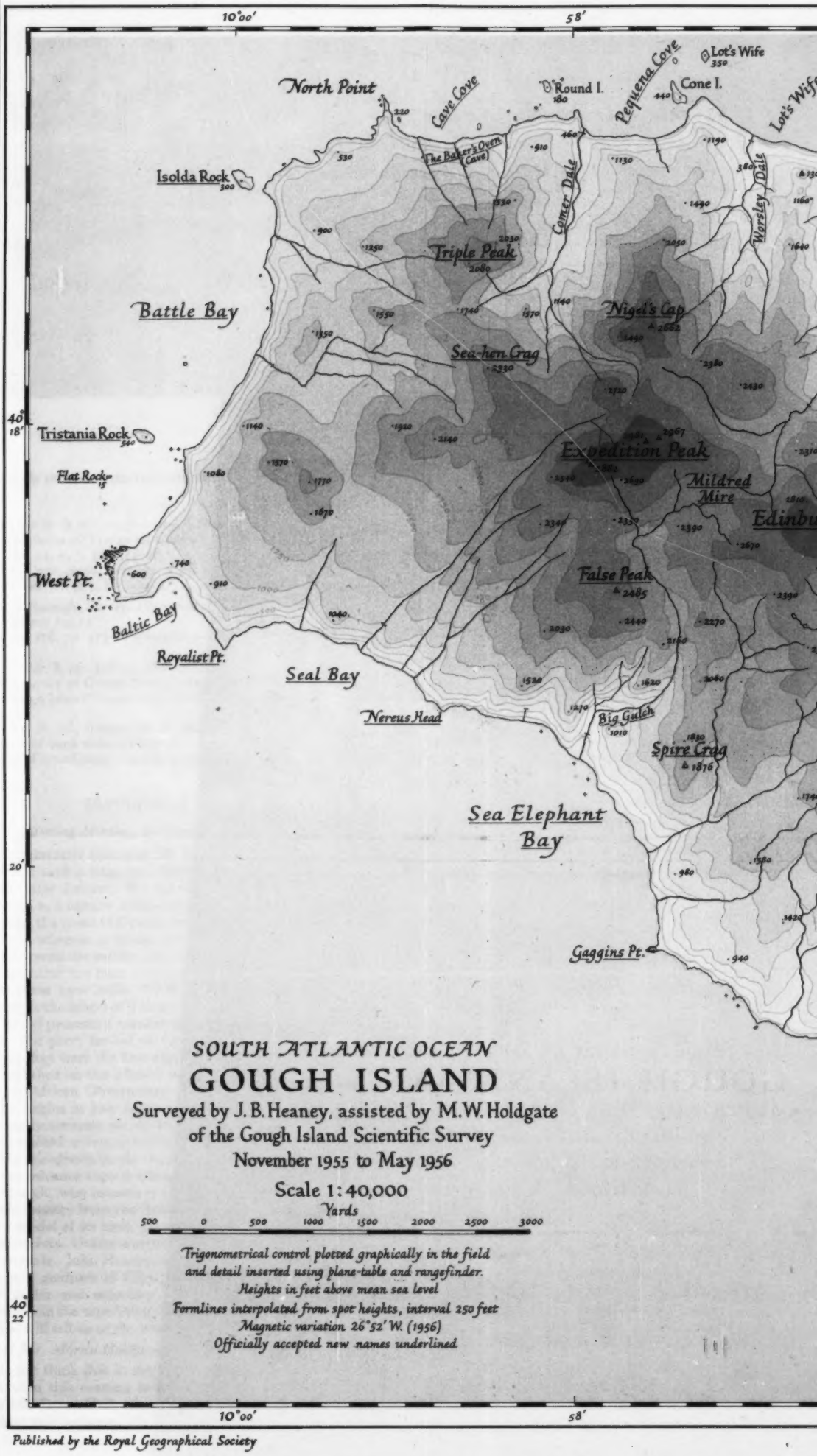

SOUTH ATLANTIC OCEAN

GOUGH ISLAND

Surveyed by J. B. Heaney, assisted by M. W. Holdgate
of the Gough Island Scientific Survey
November 1955 to May 1956

Scale 1:40,000

Yards

500 0 500 1000 1500 2000 2500 3000

Trigonometrical control plotted graphically in the field and detail inserted using plane-table and rangefinder.
Heights in feet above mean sea level
Formlines interpolated from spot heights, interval 250 feet
Magnetic variation 26°52′ W. (1956)
Officially accepted new names underlined

Published by the Royal Geographical Society

56′
54′
9°52′
Lot's Wife Cove
Church Rock
North East Point
Mt. Argus
1925
Camp Glen
Tavistock Crag
2099
Hawkins Bay
Deep Glen
First Rock
Penguin I.
Long Beach
Middle Fell
1976
Channel Rock
Reef Point
Wild Glen
Milford Bay
Tarn Moss
Kern Crag
2006
Capsize Sands
Buttress Rock
The Fid
1099
Dell Rocks
Gonçalo Alvarez
Archway Rock
Lat. 40°19′19″S.
Long. 9°53′42″W.
Hag's Tooth
2208
The Glen
Hut
North Rowett
2660
Quest Bay
Albatross Plain
Centre Rowett
2702
Mount Rowett
Sphinx Glen
Waterfall Pt.
Cave
Haystack
1647
Low Hump
2185
South Rowett
2744
West Rowett
2640
Pummel Crag
1161
Haulround Pt.
South Peak
2493
Number One
Luff Point
The Commodore
The Admiral
The Midshipman
South East Pt.
Gorsy Dale
Green Hill
1870
Transvaal Bay
Scott's Cove
Saddle I.
Stand-off Rock
Repetto Bay
Richmond Hill
690
Cavern Head
Rockhopper Pt.
South West Point
South West I.
Snug Harbour
South Point
40° 18′
40° 20′
40° 22′

HEANEY

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DISCUSSION

Evening Meeting, 22 October 1956

Before the paper the PRESIDENT (General Sir JAMES MARSHALL-CORNWALL) said: I am very glad to welcome such a large and distinguished audience to this our first Evening Meeting of the new Session. We are about to hear an account of John Heaney's recent expedition to a remote uninhabited island in the middle of the South Atlantic. That island bears the name of Gough, after a British sea captain who sighted the island in the year 1731 when on a voyage to China. It had been discovered by a Portuguese navigator two centuries earlier; the island then lapsed into oblivion until sighted by Gough, whose name has been attached to it ever since. Gough Island lies in the Roaring Forties some 1500 miles WSW of the Cape of Good Hope. The nearest inhabited territory is the island of Tristan da Cunha, which lies some 230 miles to the NNW. Gough Island presents a number of interesting features, scientific, geographic and biological. The party landed on Gough Island in November 1955 and came away in May 1956; they were the first expedition to make continuous scientific observations. They established on the island a meteorological station, which is being taken over by the South African Government in preparation for the International Geophysical Year which begins in July 1957.

For the first time a really accurate survey has been made of Gough Island. John Heaney, the leader, is a trained surveyor and he conducted the detailed topographic survey; his map is being fair-drawn in the Society's drawing office and will be published by this Society; an advance copy is being flown out to the Falkland Islands to meet the Duke of Edinburgh, who intends to visit Gough Island in January 1957 on his return voyage to this country from the Southern Hemisphere. This expedition I consider to have been a model of its kind. It was well prepared, well organized and had definite scientific objectives. Unlike most exploring adventures, the expedition did not exceed its budget estimate. John Heaney, the leader, was trained as a surveyor by the British Army; he is a graduate of Christ's College, Cambridge, and proved a remarkably successful leader and organizer. Martin Holdgate, who took over as leader until Heaney could join the expedition, is a zoologist and a graduate of Queens' College, Cambridge. He will tell us of the interesting fauna discovered on the island.

Mr. John Heaney and Mr. Martin Holdgate then read the paper

The PRESIDENT: I do not think that in this hall I have ever seen pictures that surpassed those we have seen this evening for geographic interest and sheer natural beauty. I congratulate Mr. James Hall, who took the film, and also all the members of the expedition on their still pictures. We had hoped to have with us this evening

the Hon. John Hare, M.P., Minister of State for the Colonies, but a few days ago he was promoted to another office, and could not be with us tonight. We, however, have with us one of the members of our Council, Brigadier Martin Hotine, who is Director of Colonial Surveys and therefore will represent the Colonial Office this evening. May I ask Brigadier Hotine to say a few words, particularly with reference to the excellent survey carried out by John Heaney?

Brigadier MARTIN HOTINE: I should prefer to say that the Minister of State for the Colonies has been translated, rather than promoted, to a new office, but I do know that he is interested in this expedition and is prevented from coming here this evening only by the pressure of his new duties. If I might say a word on my own behalf, to the cobbler there is nothing like leather, and you must expect me, a surveyor, to rejoice at the prospect of a new map. In square miles it may not amount to very much compared with the vast output of the large survey organizations and the still vaster areas which have yet to be done, but this is not merely a matter of square miles. Gough Island does not lend itself to mass production methods from air photographs and it presents peculiar difficulties to ground survey, one being the difficulty of getting outside it.

I am a little alarmed at the degree of specialization which seems to have been found necessary for this expedition. Almost everybody on the expedition seems to be some sort of -ologist, except the organizer who was allowed to be a surveyor. At this rate it will not be long before any expedition anywhere will require a whole boat-load of specialists, including perhaps an etymologist to write the report, and on that basis, one wonders whether David Livingstone would ever have dared to go for a walk after breakfast. Perhaps we are paying too much attention to the scientific results of these expeditions and not enough to the pioneering aspect—a simple thirst for the unknown which carries its own justification. That is merely a possible trend which we need to watch; it is not a criticism of the composition of this particular expedition whose members, I feel sure, are pioneers first and -ologists second. I would like to add my congratulations to all members of the expedition for a good job well done, and so clearly and modestly described by their leaders.

Mr. JOHN HEANEY: I do not propose to enter into a polemic in regard to Brigadier Hotine's remarks except to say that this is the age of "-ologists"!

The PRESIDENT: The lecturer has the last word and it is one I thoroughly endorse. Also I convey the thanks of the audience to two wonderful lecturers for a wonderful lecture.

A COMPILATION MAP OF PART OF THE CENTRAL ANDES OF PERU

J. V. HARRISON

SIX EXPEDITIONS to the central Andes of Peru have resulted in the production of a map covering about 7000 square miles of country on a scale of $^1/_4$ inch to a mile. The maps made during two seasons' work have already appeared in the *Journal*, but they are included in the compilation commented on in this note. The surveying was all done by planetable and range-finder and each of the six component maps is without trigonometrical control. As the areas are contiguous and as each sheet is orientated magnetic north, the various parts have been fitted together by making use of marginal points common to two sheets. The map of 1939 (*Geogr. J.* 95 (1940)) was augmented on the north and east by the work of 1945 (*Geogr. J.* 110 (1947)). In 1947[1] an area to the south-west was added and the mapping was carried nearly to the sea, whilst in 1951[2] and 1953[3] a considerable extension was made towards the north-west. The survey during 1954[4] covered a strip of country extending the map about 80 miles southwards. The heights recorded were obtained from aneroid barometers checked whenever possible against railway stations not far away.

Most of the mapped country lies within the basin of the River Mantaro or within the catchment of the streams which drain the Pacific slopes, but a small area in the east falls within the collecting ground of the Perené and neighbouring rivers. Most of central Peru is treeless, grass-covered country, but at 16,000 feet the grass peters out and only lichens hang on. Bare rocks and blown sand predominate below about 8000 feet on the Pacific slopes, a wilderness where only a few cacti and woebegone looking zerophytic shrubs can survive. Trees flourish when planted in well-watered sites in some of the highland valleys up to nearly 13,000 feet. From 10,000 feet downwards, the eastern gorges, and from a little below 10,000 feet, the slopes, are forested like the rest of the Amazon headwaters. It was a surprise to find on the sixth expedition that a few patches of indigenous woods have survived at an altitude of nearly 15,000 feet over the brow of the continental divide on the Pacific side. Small ice-fields ornament the southern slopes of the higher peaks, but the glaciers have dwindled perceptably since 1939. South-west of the watershed at about 15,000 feet, the remains of a broad plateau, undergoing erosion, can be traced to a height of about 13,000 feet within 25 miles of the coast. The plateau is more conspicuous eastwards and the Mantaro flows through what amounts to a gentle basin with peaks which are numerous along the south-western side and sporadic on the north-eastern. Although these peaks occasionally surmount 18,000 feet above sea level, they seldom have a stature of as much as 3000 feet above the average height of the neighbouring country. The population is small and consists of shepherds on the hills, miners, some of whom live at 16,000 feet, and mixed groups who live in a few towns and villages. These are established in favoured sites at about 10,000 feet above sea level where a mild climate makes agriculture profitable when water is available for irrigation. Barley and potatoes are the main crops.

The Mantaro basin.—The Mantaro River flows from the north-west end of Lake Junin and follows a direction approximately south-east for more than 100 miles. It leaves the lake at nearly 14,000 feet above sea level and, after meandering across the floors of a chain of old lakes and coursing through intervening gorges, reaches the Huancayo plain and leaves from the south-eastern part, at about 10,000 feet above sea level. Terraces are common along the valley's length, but they seem to be local features, each group recording the history of the vicissitudes of only a rather short reach of the river. A pair of well-preserved terraces at an altitude of 14,000 feet along

[1] *Bol. Soc. Geol. del Peru*, 23 (1951). [2] *Bol. Inst. Nac. Invest. Fomento Mineros*, 9 (1953).
[3] *Ibid.* 15 (1956). [4] *Bol. Soc. Geol. Peru*, 28 (1956).

the Corpacancha tributary recalls the "Parallel roads of Glen Roy" and may have a similar origin. They cannot be distinguished along the main stream nor along neighbouring valleys. Another extraordinarily perfect terrace stands at about 12,800 feet above sea level across the valleys of the Canipaca and Virgen rivers just north-west of their junction and about 10 miles from where they enter the Mantaro. The valley walls reveal masses of gravel which contribute to the formation of the plain whose perfection is remarkable. This feature may have resulted from the filling up of a great lake bed which was some 600 feet deep. Man has taken advantage of the long gorge of the Mantaro which narrows at Malpaso to erect a dam for power purposes, and this had impounded a lake 4 miles long. Below this point the river forms a rosary of open flats connected by defiles as far as Jauja where it debouches from the south on to the extensive plain of Huancayo.

For the next 25 miles the river is braided in a broad channel cut into the intermontane plain, a plain built up by river-laid gravel sheets now functioning as wide terraces a little above the bed of the river. The greatest concentration of people in the region is found here where they live in villages with plantations of gum trees set along their irrigation ditches. A few miles below Huancayo the river enters a profound gorge and runs off the map still holding south-eastwards. It is noteworthy that wherever one climbs out of the valley the view from the crest discloses a somewhat dissected plateau whose profiles run at nearly 15,000 feet above sea level. This feature is as apparent in the south above Huancayo where the climb involved is one of 4000 feet as it is in the north where from Lake Junin a climb of about 1000 feet suffices to reach a lookout point.

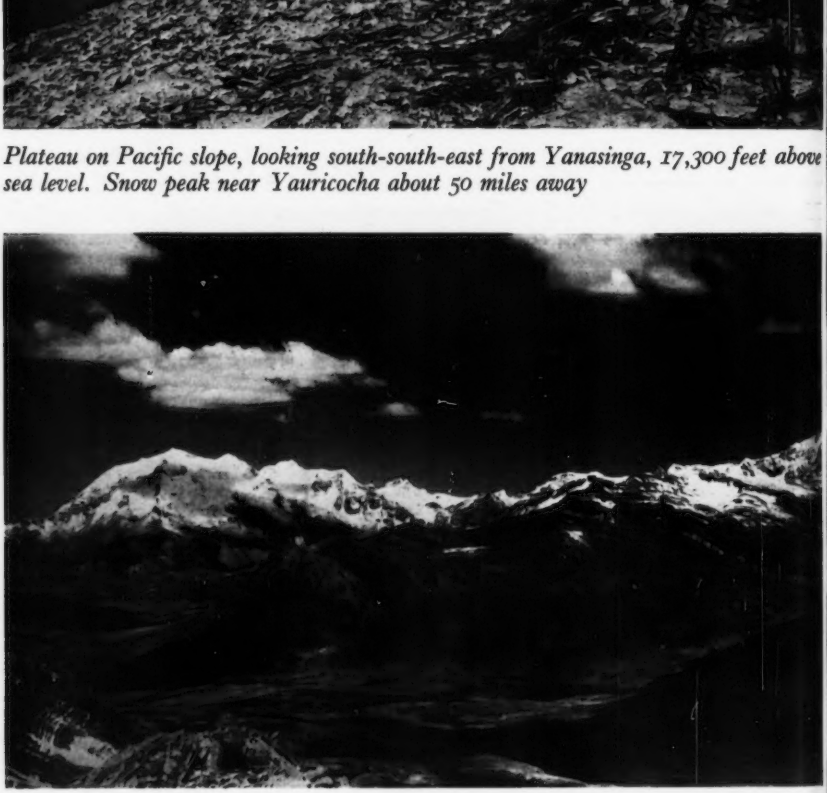
The pattern of drainage which the Mantaro collects is notably asymmetrical, the larger tributaries springing from the south-west. The collecting ground to the north-east is narrow and the run-off small, although things were very different at an earlier time when great lakes existed, nourished by extensive ice caps and held in by huge moraines, some of them 1000 feet high. The former intense glaciation has tended to obliterate earlier landscapes, but the preservation of a wind gap east of Junin and the change at this point from a rugged eastern slope to a mild western one arouse suspicion that successful piracy has been effected by the headwaters of rivers like the Paucartambo, Chanchamayo and Satipo. Even where ice still adorns the eastern rim of the Mantaro basin, as it does north-north-east of Huancayo, the reluctant thaw on the south-western slopes provides little discharge for the streams draining to the Mantaro. As a contrast, the naked aspect of the rocky slopes to the north-east mean that any precipitation here runs off at once to augment the Amazon directly. Half a dozen streams from the larger collecting ground on the right bank of the Mantaro yield a lot of water. Most of them rise in a series of vividly coloured glacial lakes from which they make their way north-eastwards. They leave the strip of relatively low country which skirts the watershed and flow north-east through gullies cutting right across a range of hills culminating in the peak of Mishipiñahui, a range which looks as if it were set expressly to bar the way of any drainage to the Mantaro from the south-west. These transverse valleys are dug in about 2000 feet and display valley-in-valley profiles. They can only have established their courses before the Mishipiñahui chain had been etched out and at a time when a surface fell gently and directly from the Western Cordillera to the ancestral Mantaro.

Another arresting sample of superposition is displayed by three streams running east towards Conocancha. They all cross the same low belt within a mile of each other and are separated by cols not more than 200 feet above water level before they encounter the chain across their paths. Each one has made its own gorge through this, each one some 600 feet deep, instead of combining behind the obstruction and letting one gash serve the three. Much of the water on the right bank of the Mantaro is fed into lakes by springs whose mode of origin is clearly demonstrated along the flanks of the magnificent seven-headed limestone range of Puajanca. Its existing glaciers, small residues of those of former days, hang above dark gullies which end below in a series of swallow holes into which all the water soaks. These are separated

Plateau in Mantaro basin, looking north-east from near Corpacancha. Raushanco, second high peak from right, about 30 miles away; river 2000 feet below, 3 miles away

Fretted edge of Pacific slope looking west from La Vichuca, 13,500 feet above sea level

Plateau on Pacific slope, looking south-south-east from Yanasinga, 17,300 feet above sea level. Snow peak near Yauricocha about 50 miles away



Nevada Tunshu c. 18,500 feet, seen from above Suitucancha looking south

from the lakes by an unnotched ridge of limestone through which the water seeps and yields many piedmont springs. One other remarkable feature on the right bank near Corpacancha is a huge outwash-fan produced long ago when a river discharged from a spout nearly 1000 feet above present stream level. Simple radial drainage, text-book consequent drainage, has developed upon this fan, but two of these streams encounter unexpected obstruction just before they reach the Mantaro in the form of a large thick cake of white calc-tufa built up after the streams had eroded their valleys. If this rocky obstacle ever succeeded in damming the valleys it does not do so now for the water has worked through it and made tunnels so that the tufa provides natural bridges.

The Western Cordillera.—The strip of mountain country whose passes lie between 15,000 and 16,000 feet above sea level and whose summits often surpass 17,000 and sometimes 18,000 feet forms the Western Cordillera. In the highest part, at Tunshu, west of Piñascocha, a large snow field still remains, but on less lofty ground only patches of stationary ice are left, thicker on the southern and thinner or absent on the northern slopes. Along some parts of the Cordillera great valleys, bare, rocky and spurless seem to have been cleared of ice within the last few years and piles of moraine lying about are so young that alpine plants and mosses have not yet become established or are only beginning to invade their lowest edge. There are a few still lower parts of the Cordillera where it merges with the plateau and the continental divide crosses it, sinuous and inconspicuous. In these saddles the lakes are larger than usual but as numerous as ever. Basins, some of them isolated, some of them strung together by the trickle of a stream, seem to occur everywhere. One of these in the south, Huarmicocha, collects the drainage from a few others but is itself completely shut in by a massive rampart of moraine and for some time past had no surface outlet. It has none now, but, about 1940, an artificial subterranean one was created, when a tunnel was constructed to add its water to supplies filched from other lakes nearby, lakes which lie within the Mantaro basin but whose water now augments, by artificial cuts, the irrigation supplies of Pacific coastal lands. The watershed runs with complete indifference along ridges of limestone, sandstone, lava or granite, but never in this area is there a recent volcanic cone on its line as there is in Ecuador, for instance. Recalling that the dissection of the terrain is so moderate in amount it is surprising that the scenery is so superb, but forms, colours and lakes combine to produce peerless landscapes.

The Pacific slopes.—This unit is less known than the Mantaro basin and may, perhaps, be considered in three parts; the plateau, the fretted edge and the coastal plain. Few people have visited the first two, nor have they been upon points from which comprehensive views over the terrain can be had, because there is nothing to entice them there. Consequently neither the extent of the plateau nor the barrenness of its fretted edge has been realized. The watershed runs about 75 miles from the coast and is roughly parallel to it. The plateau occupies rather more than half this strip and the fretted edge a little more than a quarter. To see for oneself calls for an excursion away from the roads, which keep as low as possible, and a visit to some hill such as Yanasinga above Parac on the left bank of the Rimac. From this point at about 17,000 feet, there is a magnificent prospect comprising a distant snowy cone to the south-south-east and embracing the three quadrants to south, west and north. Everywhere the profiles overlap to give a resultant surface which is nearly flat or at most gently rolling. It is of course deeply dissected where crossed by the larger rivers like the Canta, the Rimac and the Cañete which rise near the watershed and are torrents in the first quarter of the year, but become much smaller in the third. The Rimac for instance is entrenched 10,000 feet below Yanasinga although only 6 miles away from it. However, most of the other valleys are considerably shorter and accommodate streams like the Lurin or Mala which, though they carry a much smaller volume of water, are also deeply dug in. Nevertheless as seen from above, much of the plateau still seems to be preserved. In part, the rocks which have been planed off to form it are folded, but the western part is underlain by a thick cake of lavas and

volcanic ash beds lying nearly flat and they are thus in an attitude which tends to preserve the plateau or any nearly flat surface.

Taking another stance at some 13,000 feet above sea level on the western edge of the plateau, one can look out again, south, west and north and see the Pacific breakers some 25 miles away, and in between a desolate rocky wilderness in various shades of khaki falling steeply away. This is incised by a multitude of parched watercourses gathered together in bunches. One of these is Quebrada Tinaca which is usually dry for years at a time and then occasionally contains a flood of mud. Its valley, like its neighbours, is stony, uninhabited, ungrazed, waterless and inhospitable and, in this, the area to the north and south resembles it. Coastwards, the slopes give way to a multitude of spurs and stacks jutting out into or rising from the coastal plain. Where this is adequately watered, the plain is amazingly fertile, but it forms a sand-blown desert elsewhere. The plateau is almost uninhabited except for clusters of villages built along parts of the perennial streams. The fretted edge is empty, apart from the scattered alfalfa farms along the rivers that pass through it. Villages also mark the mouths of the rivers where consequently the coastal plain is irrigated.

The eastern slopes.—Three lobes on the map overlap on to the eastern slopes which lie outside the Mantaro basin. Each one more or less straddles an established route, the Huachón railway in the north, the Tarma–Perené road in the centre and the Concepción–Satipo road in the south. Heavier rainfall keeps the streams more active here than they are in the west, so that they cut back more rapidly and therefore hasten the ruin of the outliers of the plateau, a feature which is still in evidence. Thus the view from any high eastern point towards the north-east across the forested country into the haze provides an impression of a ghostly surface falling rather gently away from about 15,000 feet to something under 10,000 feet 30 miles away. The lip of the Mantaro basin is only rarely imposing on the Atlantic side, as for instance north-east of Huancayo in the Nevada de Chuspe, and even here relics of a high surface form a snow-clad massif 20 miles north-east above Tuctugococha. The more normal, unobtrusive lip is exemplified east of Junin although its course is accentuated here and there by detached spikes of volcanic rocks like Raushanco. Northwards, towards Carhuamayo, such landmarks are absent, but 20 miles east of the divide the snowy peaks of Huagoruncho rise about 2000 feet above the high plateau nearby. Again, the group of summits at Yuracmayo, 15 miles from the nearest Mantaro tributary and east-south-east of Tarma, is also well above the average surface, and there are others. These may have marked a former divide between the Mantaro and the Perené group, but now they are cut off and form outliers which remain as evidence of the energetic river erosion at present in progress. A closer view of the river pattern is interesting on account of the exceedingly narrow ravines existing for a few miles along each one where the valleys are mere slits in the mountain-side. They are ideal examples of juvenile valleys. The alps left between these gullies from 13,000 to about 9000 feet above sea level bear the potato crop which is the staple in central Peru.

A few towns have grown up along the valleys and serve as markets for the produce which is now sent to Lima. One curious effect has been left to commemorate the violent earthquake of 1 November 1947 in this region. Until the shock, the lower country was totally forested and the landscape was a study in dark greens and incredible blues, for so does the humid haze affect the colours in the distance. But now after the shock, this sombre scene is dappled with innumerable flecks of light grey, each one a scar formed by a landslide which was set going by the earthquake.

The compiled map, surveyed during six visits, shows part of Central Peru consisting mostly of plateau bordered by two ruined edges, a dry barren western one and a rainy forested eastern one. The map provides revision of a little of the country covered by the magnificent pioneer work of Raimondi and may be of service until the new Peruvian Government Survey is further advanced and more sheets of their 1/200,000 map are published.

'THE DESCRIPTION OF ESSEX,' BY JOHN NORDEN, 1594

F. G. EMMISON AND R. A. SKELTON

THE ORIGINAL contribution made by John Norden the elder (1548–1625) to county mapping and to representational technique in English cartography suggests that the discovery of a hitherto unknown manuscript by him deserves record. Unlucky in his lifetime, Norden was pursued after his death by ill fortune in the disappearance of a number of his topographical works. The 'historical and chorographical descriptions,' and maps, of five counties, which he is known or suspected to have surveyed are lost; his account of another county is known only in a printed edition of the eighteenth century; the manuscripts of four county maps, which exist in printed versions, have disappeared.[1]

Norden's survey of Essex is relatively well documented. Two manuscripts of his description of this county, each accompanied by a map, have been preserved, together with an abridged description, also with a map. Of his 'Speculi Britanniae Pars: an Historicall and Chorographicall Description of the County of Essex,' Norden dedicated manuscript copies, dated 1594, to Lord Burghley and the Earl of Essex. In the following year Norden presented to the Queen a manuscript volume containing shorter descriptions, with maps, of five counties (including Essex) and three islands. Burghley's copy, preserved at Hatfield House (and here referred to as H), was printed in 1840[2]; that of the Earl of Essex (E) is now Add. MS. 33769 in the British Museum, and the Queen's (Q) is Add. MS. 31853.

To these may be added the recently discovered manuscript (Essex Record Office: D/DMs P1), which seems to be an earlier version nearer to Norden's field survey, in time of composition and in form, than the fair copies hitherto known.

The new survey was found in the manuscripts of Hervey St. John Mildmay of Hazelgrove House, Somerset, which were deposited a few years ago in the Somerset Record Office. A selective list of deeds had been compiled by the Historical MSS. Commission,[3] but the printed report makes no mention of the Norden MS. The Hervey-Mildmay branch of the Mildmay family was originally seated at Marks in Romford, Essex, and the section of the collection representing their archives was transferred in 1955, through the good offices of Mr. I. P. Collis, County Archivist of Somerset, to the Essex Record Office, which had received the MSS. of the main branch of the Mildmays in 1940 from the Chelmsford and London family solicitors.

Comparison of the Mildmay manuscript (here cited as M) with the others throws some light on the relationship between Norden's successive versions and on his selection of material for them. Both the 'description' and the map are fair copies, but the minor slips and blemishes on the map presumably led him to reject it, and in redrawing to adopt a larger scale affording marginal space for slightly more elaborate decoration and for tables. Its dedication shows that Norden intended his work for presentation, in the first instance, to Burghley, and that H was therefore written before E. M is undated, but internal evidence points to its completion in 1594.[4] The dedicatory epistle offers further evidence of Norden's poverty and need for patronage at this date:

[1] See E. Lynam, "English maps and mapmakers of the 16th century," *Geogr. J.* 116 (1950), 15–23, reprinted in 'The mapmaker's art' (1953); and R. A. Skelton, 'Decorative printed maps' (1952), 52–3.

[2] Sir Henry Ellis (ed.), 'Speculi Britanniae Pars: An Historical and Chorographical Description of the County of Essex' (Camden Society, 1840).

[3] Hist. MSS. Commission, Appendix to 7th Report (1879), 590–3.

[4] The date borne by the lists of "howses of name," of gentry, and of justices.

. . . both my desires and abilety being smothered w^t the noysom vapors of penurie and obscurytie. . . . And now, after so manie years, and so much sorrowe, I, as one swallowed up of inevitable daungers, yelde fourth my finall imploration of yo^r good lo[rdship's] remembrance of my poore selfe and sillie suite . . . lingring hope, dismall delais, and bitter povertie . . .

The Mildmay text of 'The Description of Essex' resembles in content and arrangement that of the Hatfield and Essex manuscripts. It is divided into seven sections (the manuscripts in which each section is found being noted in brackets):

An alphabeticall table of the townes parishes and hamletes in Essex. (M, H, E.)
Howses of name . . . w^t the names of such as possessed them in . . . 1594. (M, H, E. H has, in addition 'A Table of the halls in Essex,' not in M or E.)
An alphabeticall catalogue of the names of the noble men gent and others . . . w^t their howses . . . A° 1594 in Essex. (M and E only.)
Gent. and their howses of unknowne names. (M, H, E.)
Gent. and their howses scituate in or nere Townes. (M, H, E.)
Howses somtime religious in Essex, now habitacions for gent. (M only.)
Suche as were in Commission of the peace there. Ann. 1594 . . . (M and E only.)

The text of the 'Description' is fullest in M and E, both of which have many passages not found in H, *e.g.* an account of the saffron plant, with a drawing (M, fol. 4^v). Three important sections of text occur in M, but not in E: (a) on Waltham forest (ff. 4^r–5^v), with doggerel verses on tenure and lists of the walks [1] and officers, (b) on the customs of the Honour of Rayleigh [2] (ff. 7^v–8^v), with Latin doggerel, and (c) lists of deaconries and baronries (ff. 9^r–9^v). E on the other hand has a much longer account of the rivers, eleven lines in M being expanded to 71 lines in E. The 'Description' is preceded, in M, by a note on 'The espetiall use and benefit of this book,' which is not in any of the other manuscripts, although H and Q have an explanation of the use of the 'map-references' in the lists for locating places on the map.

Like the different versions of the text, the county maps in the four manuscripts apparently all derive from a common prototype in Norden's rough draft or field notes, which are not now known to exist. The Mildmay map is the smallest in dimensions and scale. That it cannot be the only source from which the later maps were drawn is further suggested by its omission of some place-names found in the others, and by the varying representations of the road pattern given by each of the four maps. A complete collation of the nomenclature indicates that the map in M is the most reliable of the four and that it is more nearly related to H than to the others. This conclusion, which is consistent with the chronological sequence of the maps, is illustrated by the following table:

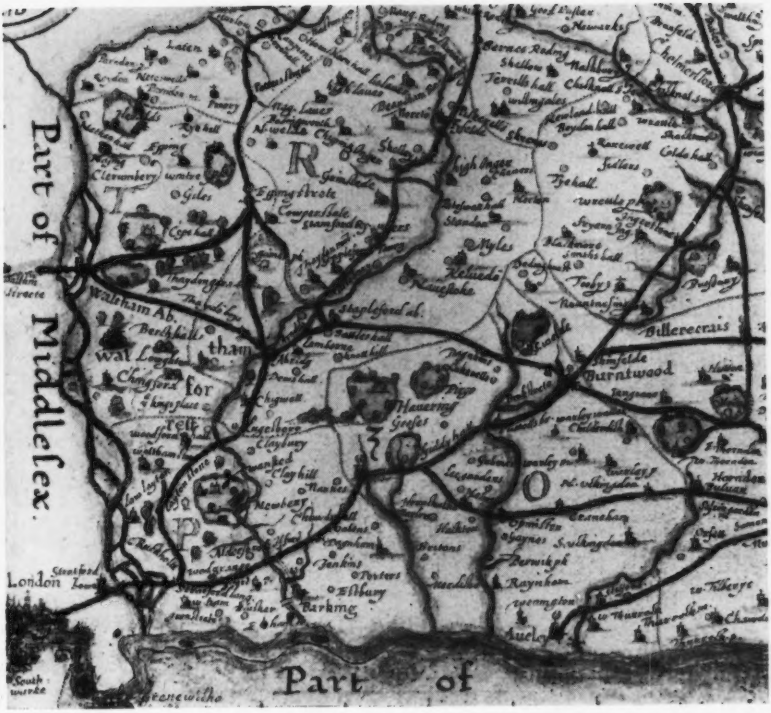
In M alone	3 names
In H alone	2 ,,
In E alone	9 ,,
In M and H (but not E) . .	10 ,,
In M and E (but not H) . .	3 ,,

Some further differences (*e.g.* the forms of names or location of symbols), in which M is superior to the later maps, arise perhaps from corruptions normal in copying; but the independent variations in H and E show that in preparing these maps Norden drew on other sketches or notes besides the map in M. No fewer than twenty-seven place-names in H are omitted—no doubt for lack of space on the smaller map—from M, which however marks all but one of these features by the appropriate symbol.

The Mildmay map of Essex is a mature example of Norden's cartographic tech-

[1] Norden's list of "walks" in Waltham Forest is earlier than any list cited by W. R. Fisher, 'The forest of Essex' (1888), p. 6.

[2] A similar, slightly longer set of doggerel verses is given in Morant's 'History of Essex' (1768), I, p. 272.



South-west corner of Norden's MS. map of Essex, 1594

Will Kemp morris-dancing from London to Norwich, 1599

nique, and displays the innovations already introduced in his maps of Northamptonshire (1591) and Middlesex (1593). The borders are graduated in a two-mile scale, numbered at top and bottom and lettered along the sides; and 'map-references' are given in the lists of places in the 'Description.' Hundreds, the boundaries of which are drawn (and agree with those in H, E and Q), are distinguished by letters, and liberties by numbers; a key is given in the text. The map has no characteristic sheet, or list of symbols. The conventional differences between the four maps are set out in the table below:

	M	H	E	Q
Size (inches) ..	9×11½	13×16½	15½×19	15¾×20
Scale	1 in.=5 m.	1 in.=3 m.	1 in.=2¾ m.	[As E]
Signature and date on map ..	none	none	John Norden 1594	none
Grid and marginal references	Scale in margins, lettered and numbered. No grid	[As M]	[As M]	[As M, but grid carried over map]
Arms	none	Royal	Royal and garter Essex and garter	Royal and garter and crown
List of hundreds on map ..	no	no	yes	yes
Indication of hundreds on map	lettered	numbered	lettered	lettered
Key to symbols	no	no	yes	no

The Mildmay map employs the full range of symbols found in Norden's other county maps, and its colouring follows the conventions of the period. The representation of settlements and important buildings is richly varied. Distinctive symbols are used for large towns, market towns, parishes, a few chapelries, a few hamlets, large, medium and small mansions, a few castles, forts or beacons, former religious houses, and some bridges and water-mills.

Perhaps the most curious feature of Norden's maps of this county is their representation of roads. Edward Heawood observed [1] that the roads in Hans Woutneel's printed map of Essex (1602) "are shown almost exactly as by Norden" (*sc.* in the Hatfield map). Closer examination, however, reveals radical variations in many parts of the road system as drawn in the four maps by Norden, each of which differs from the others and from that of Woutneel. We may cite, as an example, the roads radiating from 'Epping strete'; their delineation in Norden's manuscript maps and in Woutneel's engraved map (which seems to combine the versions of E and Q) is shown in the diagrammatic sketch on p. 40.

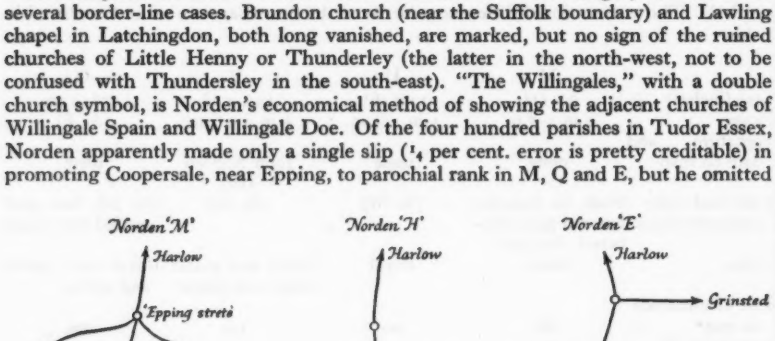
The discrepancies in Norden's representation of roads, on maps drawn within so short a period of time, must weaken the confidence of students and suggest caution in accepting the evidence of his maps for the contemporary road pattern.

There are a few particular surprises in the delineation of roads. Stane Street to the west and east of Coggeshall is missing in M and H, but not in E and Q. In M the Roman road from Chelmsford to Braintree diverges to Leighs Priory; perhaps, like Will Kemp morris-dancing to Norwich in 1599, Norden found it a "foule way" and could get no further. Is M more realistic than the others, which show a through road? On the other hand, all four show a direct road from Rayleigh to Maldon, *i.e.* going over Hull Bridge, which was then broken down and was apparently never rebuilt. Lower down the Crouch, a road (marked only by a broken line in Norden's other maps) appears in M to go right over the estuary, where Creeksea Ferry now is; but examination of the MS. under a strong glass reveals that parallel dotted lines which enclose

[1] Heawood, E. "Some early county maps," *Geogr. J.* 68 (1926) 331.

the coloured area of the roads in M do not in fact continue over the ferry which is so named on Q. The Broom Way across the flats to Foulness island is shown on all versions; and a similar track running from Manningtree to Wrabness, passable at low tide and also known from later records, is shown in H but not in M, Q or E, which marks the inland route.

Norden yields no hidden treasure to the searcher for "lost villages," but there are several border-line cases. Brundon church (near the Suffolk boundary) and Lawling chapel in Latchingdon, both long vanished, are marked, but no sign of the ruined churches of Little Henny or Thunderley (the latter in the north-west, not to be confused with Thundersley in the south-east). "The Willingales," with a double church symbol, is Norden's economical method of showing the adjacent churches of Willingale Spain and Willingale Doe. Of the four hundred parishes in Tudor Essex, Norden apparently made only a single slip ('$_4$ per cent. error is pretty creditable) in promoting Coopersale, near Epping, to parochial rank in M, Q and E, but he omitted



the name as well as the church symbol in H. Chapels of special interest include the Saxon St. Peter's-on-the-Wall, which had become a barn by the following century, and Black Chapel in Great Waltham.

The "howses somtime religious, now habitacions for gent." are well worth careful study. The list of these in the text of M includes seven former abbeys and priories for which there is no room in its map; all except two are given in the larger-scale versions. The (former) royal palaces of Havering, Wanstead, Copt Hall, Woodham Walter, and New Hall, Boreham, are shown; and the other large mansions are Rochford Hall and Hallingbury Morley. "Queen Elizabeth's Hunting Lodge," familiar to Londoners visiting Epping Forest, appears as "y^e king's place." Parks multiplied after the Dissolution. Their representation seems to accord well with other evidence, *e.g.* at New Hall, Boreham, there were the Great Park and the Red Deer Park; Norden shows two contiguous parks here, and the even larger pair at Leighs (Priory). Hadleigh and Hedingham Castles and Tilbury Fort are the only fortifications shown. Beacons are drawn at Laindon and Canewdon, and there is the well-known Walton Tower. A few water-mills are marked.

The coast-line with its marshes, islands and creeks may also repay detailed examina-

tion. Especially noteworthy on all versions are the widths of the creeks between the Fambridges and the Hollands: the latter had been dammed by 1678 (Ogilby and Morgan's map).[1] M is superior to E and Q in its record of saltings beyond the sea walls (H omits completely). Frinton cliffs are coloured brown in M, which also seems to show the miniature Butts Cliffs west of Creeksea. Norden apparently foundered, like many a good craft, on the sandbanks beyond the Maplin Sands: the south-east corner of M is a replacement, neatly inlaid. Possibly Norden had attempted to insert the table of hundreds (as in the larger maps) but felt he had overcrowded M. The substitute is probably an improvement aesthetically, and we feel confident that the fish will escape from the pursuing monster! This drama of the sea is not portrayed in the other maps.

Any attempted assessment of Norden's (or other early cartographer's) reliability takes into account evidence of known errors. Apart from the roads, Norden's errors are remarkably few. Little Dunmow, ¾ mile south of Stane Street, is placed on the road in all the versions; they are also equally incorrect in siting Brook Street well off, instead of on, the Brentwood–London road. We find "Billerecrais" in M, no doubt due to assimilation to the adjacent Ramsden Crays. Billericay is one of the few etymological puzzles which 'The place-names of Essex' (E.P.N.S., XII) could not solve. It has puzzled cartographers, too: Oliver, in his map of Essex (1696),[2] made one of his rare blunders with "Build upon Cave *alias* Billericay" which looks as though he was the victim of leg-pulling at the inn; but the other Norden maps correct H in omitting the alien 'r'. Norden must be exonerated from two apparent errors which those not familiar with the topography of Tudor Essex might "spot." "Shenfelde" and "Dagnhams" were both small mansions, not to be confused with the villages, correctly marked in each case 8 miles to the south-west. The first was later renamed Killigrews; the second has misled people down to the present century. "Thurrock M(agna)" in M is interesting, and this natural counterpart to Little Thurrock is otherwise unrecorded except in Morden (1695). Did Norden invent it, having forgotten to note its normal name, or was this a contemporary variant? His other maps give the Grays form. (Great) "Ilford" is correctly marked as a chapel in the parish of Barking; the ancient parish of Little Ilford, now absorbed into East Ham, appears as "Ilford p(arva)." The old town of Chipping Ongar, despite its name, is not credited with a market in the description on the map; a list of market towns in 1575, preserved in the quarter sessions rolls,[3] likewise omits this place. At four centuries' distance we can see a draughtsman's slips. Names added later, *e.g.* St. Ayletts near Saffron Walden, occur here and there, recognizable by the use of a different quill. More interesting is the insertion of names against the wrong village sign, corrected by a brace to the right symbol: *e.g.* Greenstead near Colchester had first been written against Elmstead church, and "Canonden" (for Canewdon).

[1] Reproduction, 1953 (Essex Record Office Publications, No. 24).
[2] Reproduction, 1947 (Essex Record Office Publications, No. 5).
[3] Essex Record Office Q/SR, 55/3.

Note.—The very fine detail, exquisitely drawn in the Norden Mildmay MS. map, has been very faithfully reproduced by Waterlows, who have overcome one or two technical problems satisfactorily. The fact that the Frinton cliffs were coloured brown, not red, was not noticed until the reproduction was received: testimony to Waterlows' care. It is very slightly clearer than the original, and the tiny writing can easily be read without a magnifying glass by those with normal eyesight. The reproduction leaves no doubt that it is from a MS. drawing, hand-coloured, not a coloured engraving, and the whole appearance give the "feeling" of the original, with its slight irregularity in the colouring, its slips, and its little blemishes, such as Norden's red ink smudges which can be detected in several places. As the Mildmay map is the smallest in size, it is the least expensive to reproduce as a facsimile in full colour. The area of the map within the frame is 9×11½ inches and the reproductions are on Ivorex card, overall size 12×14½ inches. Copies are obtainable from the County Archivist, Essex Record Office, County Hall, Chelmsford, or from the office of the Royal Geographical Society, at 2*s* 6*d* each (post free in tube 3*s*).

SOME INVESTIGATIONS INTO SOLIFLUCTION FEATURES IN NORWAY

P. J. WILLIAMS

THIS PAPER describes studies which have been carried out during the last two years, of various forms of solifluction in the mountains of central Norway. The field-work has been undertaken by expeditions with members from Cambridge and Oslo Universities.[1] It has been supported by the Society, the Norwegian Nansen Fund and several other sources. The investigations are planned to continue for several years, and some of the suggestions made in the latter part of this paper concerning solifluction processes are necessarily tentative. Solifluction, or the downslope movement of soil due to periglacial conditions, occurs in many forms in Norway, but the field investigations have been largely confined to certain forms which will first be described in detail. We have set out to answer two main questions: What is the rate and extent of movement of soil in solifluction features, and, hence, what are the processes giving rise to the development of these features? A short account will be given of some of the experimental methods being used in the field work, and possible causes for the developments of the solifluction features will then be discussed in the light of our observations.

Main solifluction forms investigated

Large solifluction terraces on slight slopes.—Well-developed solifluction terraces (Plate 1) have been investigated on slopes of 5°–20°, near Reinheim, Dovrefjell, on a probably large outwash fan, and in Trollheimen (Plate 2), where they occur on morainic and talus deposits at the foot of the south-east scarp of Blåhø mountain. Similar terraces occur locally elsewhere in Norway (*e.g.* Rondane). They have steep frontal banks, often more than a metre and sometimes at Blåhø over 2 m. high, occurring at intervals of some tens of metres upslope. The distance varies considerably, and it decreases as the slope increases, while the height of the frontal banks often increases with increased slope.

The form and height of the frontal bank varies considerably within a small area and probably represents different stages in the development of the terrace (see Fig. 1). Many of the larger frontal banks are bulging outwards, and in some cases it is possible to insert a hand 10–20 cm. into a roughly horizontal crevice at the base of the bank. Frequently the highest banks are in an apparently collapsed state. The vegetation cover shows corresponding variations. In plan the terraces are somewhat lobate in form, and commonly the frontal banks are not parallel to the contours. Figure 1 shows a map of part of the Blåhø area. Here the terraces have a remarkable surface drainage system. Branching streamlets, originating from 2–3 meltwater streams, flow down the scarp face and spread over the terraced area. Individual streamlets often flow along the bases of the terrace fronts. The vegetation cover is usually fairly complete and there is often a conspicuous zonation over the terraces. Internally, a section dug into a terrace, perpendicular to its front, shows a humus layer which is a continuation of the surface vegetation immediately downslope of the front. Figure 2 shows such a profile inside a large terrace. The humus layer becomes increasingly decomposed further in the terrace but often persists inwards for several metres. In the profile shown it was clearly distinguishable for 13 m. Several smaller humus layers at different depths may occur in the frontal part of the terrace. The soil is morainic and large stones and boulders are abundant. The latter are commonly

[1] 'N.E.A.T. Preliminary report of investigations into certain solifluction and patterned ground features in Norway.' Duplicated and privately distributed, Cambridge, 1956.

lying parallel to the terrace surface, as is to be expected if the velocity of soil movement varies with depth. The stones are often accumulated under humus layers, and frequently there are many stones and boulders arranged peripherally under the surface of the frontal bank.

The humus layer by its progressively decomposed nature indicates that movement of the terrace front downslope has been gradual. The 13-m.-long humus layer shown

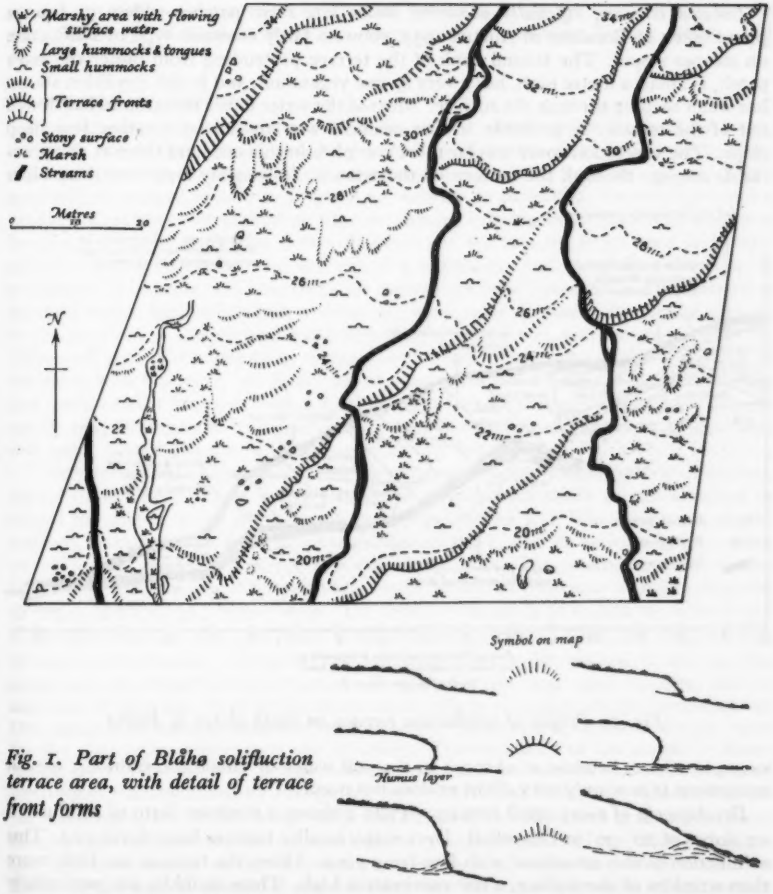


Fig. 1. Part of Blåhø solifluction terrace area, with detail of terrace front forms

on the profile represents an advance of the front over at least that distance in post-glacial time—in this area perhaps 6000 years. In fact, this advance probably occurred in a much shorter period as much of the soil material itself is apparently derived from the scarp face above the area. Similarly, sufficient vegetation to give a marked humus layer would not have developed for some time after the retreat of the ice. This implies movements of 3 mm. per year and more, over some considerable time. It is likely that the terraces have periods of activity related to climatic and other factors. Movement in recent years is indicated by the little-decayed condition of the humus layer immediately behind the frontal bank, but the surface vegetation indicates this

movement as relatively slight. There is clearly scope for pollen analysis of the humus in different parts of the layer. Studies of the present surface vegetation are largely concerned with the presence or absence of species or communities associated with soil instability due to solifluction. *Betula nana*, *Salix lapponum*, and *Nardus stricta* occur on the terrace surfaces, and Hr. Eilif Dahl [1] has shown that these species cannot tolerate certain forms of solifluction. It is, however, not certain that the type of soil movement occurring in these terraces is the same.

Isolated terraces, especially occurring under late snow patches.—Plate 3, from a photo taken in Rondane in August 1955, shows a fairly common type of solifluction on steeper slopes. The frontal bank of the terrace protruding from under the snow patch, is about a metre high, has a very sparse vegetation, and in the condition shown has water seeping through the surface. Most of the water in the foreground has flowed out of the terrace. A probably similar example was studied on a rather less steep slope. The vegetation cover was far more complete in this one, and there is no appreciable seepage through the surface of the terrace. It possibly represented an older

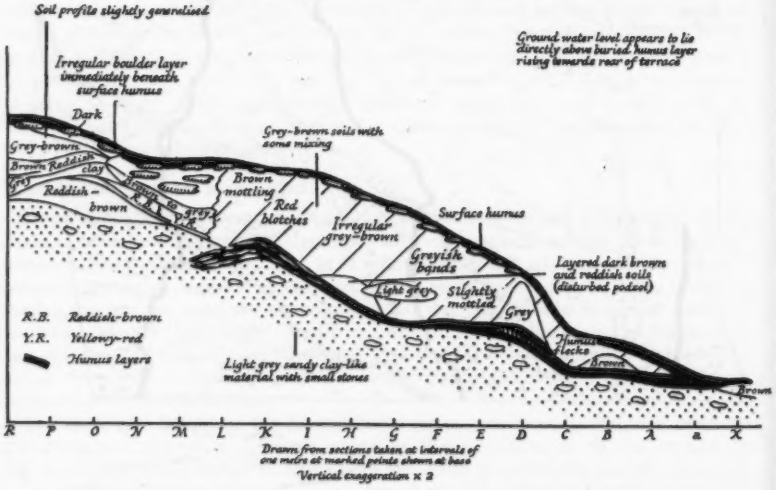

Soil profile slightly generalised
Irregular boulder layer immediately beneath surface humus
Dark
Grey-brown
Brown
Reddish clay
Grey
Reddish-brown
Grey-brown soils with some mixing
Brown mottling
Red blotches
Irregular grey-brown
Ground water level appears to lie directly above buried humus layer rising towards rear of terrace
Surface humus
Greyish bands
Layered dark brown and reddish soils (disturbed podsol)
Light grey
Slightly mottled
Grey
Humus flecks
Brown
Brown
R.B. Reddish-brown
Y.R. Yellowy-red
Humus layers
Light grey sandy clay-like material with small stones
R P O N M L K I H G F E D C B A a X
Drawn from sections taken at intervals of one metre at marked points shown at base
Vertical exaggeration × 2

Fig. 2. Profile of solifluction terrace on south slopes of Blåhø

example where, because of changes in the soil water or climatic conditions, annual movement is now only very slight or does not occur.

Development of many small terraces.—Plate 4 shows a common form of solifluction on slopes of 20°–30° in Dovrefjell. Here many smaller terraces have developed. This solifluction is also associated with late-lying snow. Often the terraces are little more than wrinkles of the surface, a few centimetres high. These wrinkles are particularly associated with the latest-melting snow patches, and during the melting of the snow are extremely wet. Wrinkled areas are often clearly delineated, roughly rectangular, several metres wide, and extending many metres downslope. Digging into these structures reveals many contorted humus layers within the first 5–20 cm. of the surface, showing that there is a definite movement of material over itself. Hr. Dahl has recorded downslope movements of the surface soil of up to 0·5 m. per year in this type of solifluction, by recording the positions of lines of stakes annually. His experiments

[1] I am indebted to Hr. Dahl for information on the susceptibility of various species to solifluction.

also show that movements in this type of solifluction are highly irregular, several years elapsing without movements of more than a centimetre being recorded. It is obvious that this type of solifluction represents a downslope movement of material many times greater than that of the large solifluction terraces on slight slopes. Parts of the steep slopes where this type of solifluction occurs can be distinguished even when no conspicuous terrace or wrinkle features are formed. The presence of *Salix herbacea*, *Phyllodoce*, *Cassiope*, and *Juncus trifidus*, indicate solifluction, while certain species are always absent where solifluction occurs, notably the Arctic Birch, *Betula nana*, Billberry, *Vaccinium myrtillus*, *Arctostaphyllos uva-ursi*, *Nardus stricta*, and *Salix lapponum*.

Experimental investigations

The experimental investigations must be largely considered as in an early stage, and such conclusions as can now be drawn from them are often incidental to their main purpose. A number of long-term experiments have been set up which are primarily concerned with recording soil movement. In particular, the vertical velocity profile (the relative movements at different depths) is being investigated. In 1954 ten lengths of lead cable (8 mm. outer diameter and up to 2 m. long) were laid vertically in narrow boreholes with the aid of a plumbline, and carefully packed in by pouring mud into the hole. Several were reinvestigated last year in the large Reinheim terraces, where fairly slight movements only were to be expected. By careful digging it was possible to observe the cable held tightly in the soil, and irregularly curved. The small size of the distortion together with some uncertainty of the alignment of the cable after insertion, led to the use of a narrower borer (about 2·5 cm. diameter) and more careful insertion with a further eight lengths this summer. More definite results may be expected in a year or two. Another experiment involves 15-cm.-long iron nails, placed one above the other in similar boreholes.

Direct recording of the solifluction movements is being carried out with probes, consisting of flexible metal strips with electrical resistance strain gauges attached to record curvature, which are inserted vertically into the soil. The strips are of aluminium, duralumin or steel, about a millimetre thick, and of various lengths from 30 cm. to 2 m. The width varies from 2·0 cm. to 5 cm. The resistance strain gauges consist of a filament of constantan wire whose measured resistance is highly sensitive to strain, attached to a paper strip. The effect of strain is to reduce the size of the cross-section of the wire, and hence to reduce the resistance. There are various forms of gauge on the market. The gauge is glued to the object to be strained, in this case the metal strip, by one of several types of adhesive. Gauges were used in pairs, one on each side of the strip. In this way temperature effects are automatically compensated. One gauge is in tension while the other is under compression, so that a double value for the change in resistance is also obtained. The resistance of the gauges is determined by a Wheatstone's bridge arrangement, and we used a valve-compensated instrument manufactured by Philips for field-work. The resistance values obtained are measures of the strains of the strip, and hence of the curvature it has undergone. Strains may be measured with an accuracy of 5 micro-strain with the Philips bridge, and this corresponds to the very small curvature of a metre-long strip, where the centre of the strip is displaced about 1 mm. with reference to its ends. Considerable care must be taken to waterproof the gauges. The use of various waxes and cold-setting plastics was tried, but these were not entirely successful. It is fairly certain, however, that some type of plastic will eventually prove satisfactory. When the probes were inserted into frozen ground, the readings of the measuring bridge remained approximately constant. As the thaw progressed, the gauges at each depth began to indicate movements of the soil. The movements seemed often to be rather irregular, although showing persistent tendencies over several hours or days. In one case at Reinheim, a probe 30 cm. long, inserted to its full length just behind the frontal bank of a large terrace, showed progressive curvature over several days, the readings then

becoming steady. Some rather regular changes in the rate of curvature seemed to occur diurnally. The curvature was eventually confirmed by examination of the probe *in situ*. The soil was carefully dug away from the side, the curvature then being clearly visible. Similar curvatures were recorded for other probes, and in many cases movement could be caused by disturbing the neighbouring ground, for example, by jumping on it.

A fuller programme of observations is to be undertaken this summer with an improved form of this apparatus. By repeatedly indicating not only relative movement in different layers, but also the time of movement, the instrument has considerable advantages over other methods. Mention may also be made here of an instrument constructed for soil temperature measurements, which uses the relatively new, and very sensitive, electrical resistance thermometer, the thermistor. In addition to the usual type of mercury soil thermometer for temperature recording at depths of up to 0·5 m., there is a need in these investigations for a sensitive thermometer which can record temperatures with accuracy at a greater depth, while causing a minimum of disturbance to the soil. The thermistor has considerable advantages over a thermocouple system, in that it is much easier to measure the changes in relatively large resistances than to measure the size of very small E.M.F's, especially under field conditions. The thermistor is also considerably cheaper than other forms of resistance thermometer.

The thermistor type [1] used was the Stantel F 3311, with nominal resistances of 4000 ohms at 0° C. and zero at 200° C. It consists of a glass tube measuring 3·82 mm. in diameter and 77 mm. in length, with the thermo-element (a complex mixture of metallic oxides) sealed into one end and the connecting wires sealed through the other. Outwardly, the completed thermometer consisted of a 2-m.-long, fairly rigid plastic tube with a bullet-shaped brass tip. The thermistor itself was mounted with wax in a hole drilled down the centre of the brass tip to within 0·5 cm. of the tip. The brass was machined so as to be a tight fit in the end of a polyvinyl-chloride plastic tube (outside diameter 1·3 cm.) and form a smooth-pointed end. The leads from the thermistor ran through the plastic tubing. The length of the tubing could be increased to 5 m. if necessary. The instrument was very convenient to handle and could be pushed down a borehole, or pushed into soft earth without boring. The thermistor, held in the brass cap, was safe from damage by bending of the plastic tube. Heat conduction through the brass was rapid and the temperature reading stable after about 15 sec. Calibration of the thermistors was carried out in flasks containing solid carbon dioxide and alcohol, and the estimated accuracy of the calibration was $0{\cdot}1 \pm 0{\cdot}05°$ C. With a high-quality bridge, however, thermistors may be used to obtain temperature readings with a much greater accuracy.

Causes of movement in the various forms of solifluction described

Although the experimental investigations with the use of the instruments described are incomplete, our observations have led to consideration of a number of processes which may be active in causing solifluction. It is hoped that, eventually, further results will show the relative importance of these.

Preliminary consideration: structure, ice content and volume of a frozen soil.—Before discussing those processes occurring at thawing which could cause solifluction, it is necessary to consider the nature of the frozen soil. It is often observed that frozen ground contains layers, crystals, or occasionally masses of ice.[2] In Norway it is common to find soils with abundant ice layers often with only some millimetres

[1] A good account of thermistors is given in: C. H. Mortimer and W. H. Moore, "The use of thermistors for the measurement of lake temperatures," *Int. Ver. f. Theor. u. Ang. Limnol. Mitt.*, No. 2. Stuttgart, 1953.

[2] Illustrated in, for example, G. Beskow 'Tjälbildningen och tjällyftningen med särskild hänsyn till vägar och jernvägar' (with English summary). *Sverig. Geol. Under Ser.* C. N:o 375, 1935.

1. Solifluction terrace, near Reinheim, Dovrefjell, Norway

2. Solifluction terraces at foot of south-east scarp of Blåhø mountain, Trollheimen

3. Isolated terrace under late-snow patch on steep slope: Rondane, August 1955

4. Small terraces on steep slope, associated with late-lying snow. Near Reinheim, Dovrefjell

between them, lying roughly parallel to the surface, and varying from less than a millimetre to more than a centimetre thick. Only soils of certain grain-size composition have this property of forming free ice in layers, crystals or masses larger than pore size. Other soils, however the temperature or water relations of the area may vary, do not show isolated ice when frozen. These two groups may be called frost-susceptible (or frost-heaving), and frost-stable, soils.

Freezing of frost-stable soils results in a volume expansion of at most 10 per cent., *i.e.* it is an expansion due to the water contained in the soil before freezing. Frost-susceptible soils may have an expansion of 45 per cent., and such enormous expansion is due to a great increase in the water content of the soil at freezing. The expansion shows itself as a raising of the ground surface (frost-heave). Natural solifluction and patterned ground features, as well as frost damage on roads, railways, etc., are frequently due to the presence of such soils.

In an important series of experiments Beskow [1] found relationships between various factors in the soil of a given locality, and the nature of ice formation in it. These factors are:

(a) Grain-size composition: Grain-size composition shows within fairly precise limits whether a soil is frost-susceptible or not. Only if the soil is nowhere capillary saturated, or if the rate of freezing is far greater than probably occurs in nature, will an apparently frost-susceptible soil (as shown by grain-size analysis) not show some free ice when frozen.

The upper grain-size composition limits for frost-susceptibility in morainic soils the soil type commonly found where solifluction occurs in high mountain areas in Norway) is shown in Fig. 3. The cumulative percentage composition curves for the coarsest commonly frost-heaving soil (pecked line), and the finest never frost-heaving soil (hachure continuous line, both after Beskow) are shown in Fig. 3. The composition curve for sample 3, from 1·3 m. depth in a solifluction terrace near Reinheim, is also shown. (Those fractions of the sample over 2 mm. diameter are not included in the analyses, as they are not generally of significance in the determination of frost susceptibility.) There is theoretically also a lower grain-size composition for soils in general (many clays being not very frost-susceptible), but this need not concern us.

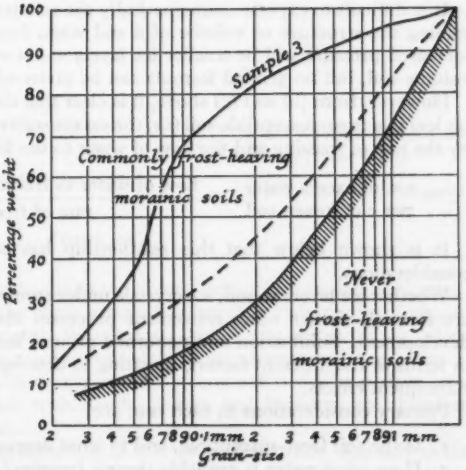


Figure 3

(b) Water availability: The substantial increase in the water content of the soil to give free ice (generally as ice layers), is the result of water moving up towards the freezing surface. This movement is due to a continuous adsorption of water molecules onto the ice surface, causing the growth of ice layers and a consequent flow of water in the neighbouring soil towards the ice. The reasons for the initial ice separation are not fully understood, but the movement of water is explained by Beskow and others as being analogous to the process

[1] Beskow, G., *op. cit.*

occurring when water evaporates from the surface of the soil, and is replaced from below by capillary action.

For a given morainic soil, other factors remaining constant, the amount of ice formed, and the size of ice layers, are governed by the water supply to the ice surfaces (*i.e.* at the boundary between the frozen and non-frozen soil) while the soil is undergoing freezing. If this is small only small ice layers will have formed before the boundary between the frozen and non-frozen soil moves further down. If however the supply is larger and fairly continuous (as will be the case if there is a capillary connection with an abundant water source, *i.e.* if the distance to groundwater is small), the layers will be larger.

(c) Rate of freezing: Considering a soil with a given water availability, the significance of variation in the rate of freezing can now be seen. A decrease in the rate of freezing will result in larger ice layers, for the boundary between the frozen and the non-frozen soil will move downwards slower, giving time for a correspondingly larger movement of water to each layer. Conversely, an increase in the rate of freezing will result in a decrease in the size of ice layers. It has been shown experimentally that a very rapid freezing produced no visible free ice in frost-susceptible soil. Theoretically, a very slow freezing and abundant water will give an infinitely large ice layer, and no sinking of the boundary between the frozen and non-frozen soil.

(d) Pressure: Increased pressure reduces the rate of flow of water to the ice surface, and its effect may be considered as that of a change in water availability. (Pressure here is to be considered as the total pressure normal to the ice layer surface.)

(e) Other factors: Both the amount and form of the ice are to a lesser degree affected by the presence of salts in the soil solution, the soil's mineral composition, degree of compaction, etc. Factors such as the vegetation cover and climate, of course play an important but indirect role.

It is difficult to express mathematically the relative effects of these factors in determining the structure or volume of a soil when frozen. The result, for example, of increased pressure will be smaller ice layers and a smaller increase of water per unit volume soil, but no general formula can be given which will cover this effect.

However, from (b) and (c) above, it is clear that the distribution of the excess water (as ice) in a frost-susceptible soil (*i.e.* the excess water per unit volume soil) is governed by the rate of freezing and the flow of water to the freezing surface:

$$\frac{\text{c.c. of excess water}}{\text{per c.c. frozen soil}} = \frac{\text{flow of water to freezing surface (c.c./sq. cm./hr.)}}{\text{rate of freezing (c.c./hr.)}}$$

It is shown below that this relationship has considerable value in theoretical considerations.

Whether ice layers in soil, ice crystals under stones or in soil, or other ice structures are formed, similar water movement processes obeying certain laws control their development. Solifluction and patterned ground features are often to be interpreted in terms of the different factors operating to determine ice formation in them and its subsequent effects.

Primary considerations in each case are:

1. Is the soil frost-susceptible, and to what degree?
2. If so, what water is available during freezing? (Depth of groundwater level?)
3. What is the rate of freezing?
4. What is the depth of frost penetration?

Significance of ice layer formation and frost-heave

The great frost-susceptibility of the soil of the Reinheim and Blåhø large solifluction terraces is verified by grain-size analyses (see curve for sample 3, in Fig. 3), and by field observations of abundant ice layers up to 0·5 cm. thick and 15–20 per cent. of the height of a 15-cm. soil column. The generally high groundwater level,

and the long periods of freezing temperatures [1] shown by the deep frost penetration and soil temperature measurements in July 1955, mean that considerable frost-heave occurs. A frost penetration of at least 1 m. is general over the terraces so that with the free ice formation observed, a surface frost heave of at least 15 cm., and perhaps more than 0·5 m. can be assumed. Permafrost has not been observed.

The other types of solifluction described—those which occur on steep slopes—do not appear to be restricted to areas of frost-susceptible soil. The significance of ice layer formation and frost-heave are therefore best considered with reference to the large solifluction terraces of slight slopes. The forms of solifluction not restricted to frost-susceptible soils, and where ice layer formation and frost-heave are only contributory, although often important, factors, are considered last.

"Creep" effect of frost heave.—Frost-heave occurs as the result of an increase in water content at freezing; at thawing the excess water will disperse and the soil, if on level ground, will sink back to approximately its original position. On sloping ground, however, frost-heaved soils will usually have a downslope component of movement

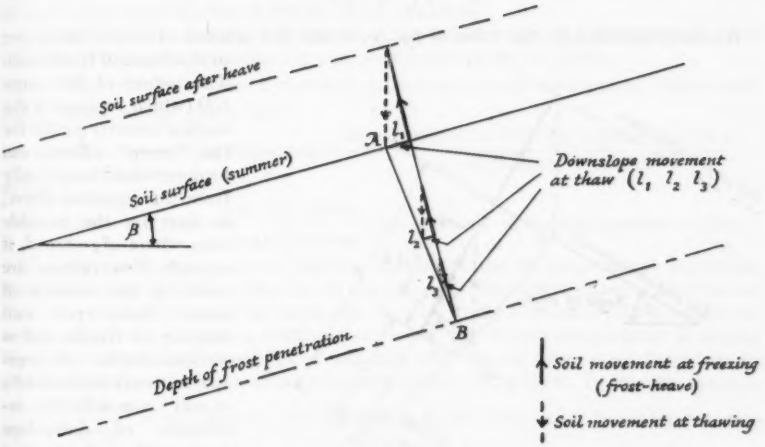


Figure 4a

at thawing (see Fig. 4a). This may be called the "creep" effect of frost-heave ("creep" here is not to be confused with the more complex "creep" or "plastic flow" phenomena of clays and similar substances). Where, for example, the surface of a 5° slope is raised 0·5 m. by frost heave, a maximum downslope movement of 4·4 cm. is theoretically possible at thaw. The maximum movement will occur at surface level and the movements will decrease with depth. Stones and boulders are therefore turned to lie parallel to the surface.

Figure 4a shows the movements occurring in one freeze-thaw cycle, due only to the "creep" effect of frost-heave, in the theoretical case of a soil profile where all the factors governing the formation of ice layers (and hence frost-heave) are the same at all depths. It is assumed also that the soil sinks into position exactly vertically, and that the "creep" effect is therefore at a maximum.

In nature, layers of different grain-size composition, different rates of freezing, varying distance to ground water, and other factors, result in a varying water increase per unit volume of soil at different depths, such that the frost heave is not proportional to depth, and the maximum downslope movements, l_1, l_2, l_3, etc., cannot be

[1] *Det Norske Met. Inst. Årsbok*, 1954, etc.

represented by a straight line (*AB* in Fig. 4a) but by a curve of the type *CD* in Figure 4b. The increments of downslope movement, Δl, are proportional to those of frost-heave ΔE, and to A_β where A_β is a factor governed by $\tan\beta$, the angle of slope.

$$\Delta l = A_\beta \Delta E$$

In Figure 4b, ΔE is the expansion (occurring only in a plane normal to the surface) due to the ice layers in a layer of soil of thickness ΔX at depth $(P-X)$.

ΔE=(time of freezing of ΔX) (flow of water to freezing surface at depth $(P-X)$)

so that

$$\Delta l = A_\beta f_{(P-X)} \Delta X$$

where $$f_{(P-X)} = \frac{\text{flow of water to freezing surface at depth } (P-X)}{\text{rate of freezing}}$$

and the curve *CD* is given by

$$l_x = A_\beta \int_o^x f_{(P-X)} \Delta X$$

As shown previously, the value of $f_{(P-X)}$ is also the amount of excess water per unit volume of frozen soil. The nature of the curve *CD* (which represents the vertical velocity profile for the "creep" effect), can be determined empirically from the equation above, at least for the possible case where $A_\beta = \tan\beta$, if enough observations are made of the amount of excess water per unit volume of frozen soil at various depths. (If regelation occurs substantially it will cause a further increment of downslope movement, and sampling of the soil will be necessary for each freezing.)

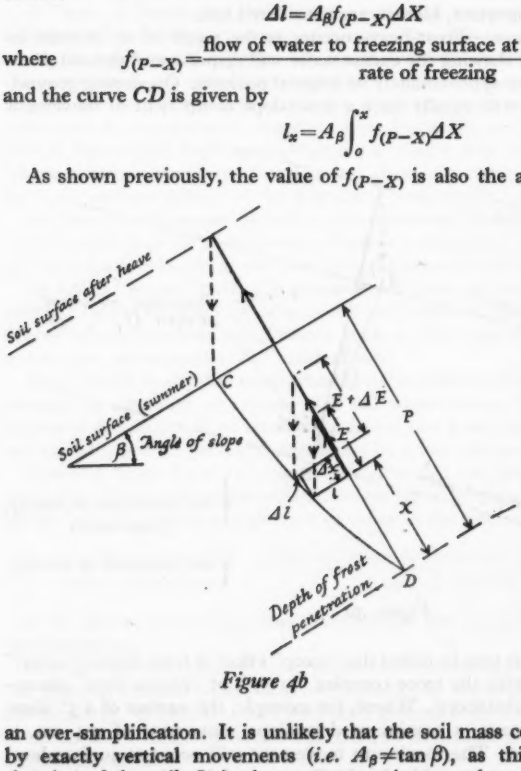


Figure 4b

This treatment of the "creep" effect of frost-heave is almost certainly an over-simplification. It is unlikely that the soil mass consolidates after frost heave by exactly vertical movements (*i.e.* $A_\beta \neq \tan\beta$), as this would imply substantial shearing of the soil. It is also open to conjecture what soil movements occur at the faces of melting ice layers. Some "creep" however seems inevitable. The heave occurs against the force of gravity, the centre of gravity of each particle being moved slightly outwards and downslope, while the resettling occurs under the force of gravity. Were the soil to return to its original position, an additional upslope component of force would be required, to overcome the downslope component of the force of gravity. If the soil at the same time is in an unstable equilibrium as a result of one or more of several other effects to be described, then the "creep" effect may reach its maximum, although this may be partly obscured by movement due to other causes. The curve taken up after thawing, by any easily flexible strip inserted into the soil, also probably represents the vertical velocity profile. It is intended to compare results obtained for the vertical velocity profile by instrumental determinations

with strain gauge probes, lead cable, etc., with those obtained for *CD* from the equation developed above.

Possibility of flow due to excess water from melting ice layers.—The commonest theory of the cause of solifluction is that the soil is reduced to a plastic consistency by the excess water, from both melting ice and snow, in the soil at thaw. The possibility of this must be considered critically for each case of solifluction. In the large terraces of the Reinheim type its significance is to be doubted. Water is generally present in slight surface depressions throughout the summer (in the drought of 1955 wide areas of the Reinheim terraces lacked any visible water, but this was exceptional), and during the thaw the groundwater level is usually found to be just below the soil surface. Capillary saturation alone therefore is assumed not to produce soil flow since this would imply that the terraces could occur equally well without frost action. If water remains in the crack left by a melting ice layer this might cause sliding movements, or mix with the soil particles around to produce a locally fluid material. The water from the melting ice layers will only accumulate, however, if the rate of liberation of the excess water by melting exceeds the rate of the (upward) movement of water away from the top of the still frozen soil layer.

Considering first the rate of liberation of the excess water, it is clear that in a soil column of cross-sectional area 1 sq. cm., thawing from the top down

rate of libn. (c.c./hr.) = (rate of thawing c.c./hr.) (c.c. excess water per c.c. frozen soil)

and as shown earlier (see p. 48):

$$\text{c.c. excess water per c.c. frozen soil} = \frac{\text{flow of water to freezing surface (c.c./hr.)}}{\text{rate of freezing (c.c./hr.)}}$$

so that

$$\text{rate of libn. (c.c./hr.)} = \frac{\text{rate of thawing}}{\text{rate of freezing}} \text{ (flow of water to freezing surface c.c./hr.)}$$

The rates of thawing, and of freezing, depend on the air temperature, insolation, the depth in the soil, the diffusivity of the soil, etc. The rate of thawing may be less than the rate of freezing of the same soil, because in the latter case heat is conducted away through an increasing thickness of frozen soil, whose conductivity is greater (by up to 30 per cent.) than that of unfrozen soil. On the other hand there may be greater insolation tending to give a relatively higher rate of thaw. In any case the ratio $\frac{\text{rate of thawing}}{\text{rate of freezing}}$ is not likely to vary more than from 1 : 2 to 2 : 1. From the equation derived above, the rate of liberation of the excess water at thaw must be of the same order as the rate of water movement to a freezing surface in the same soil. By comparison with data given by Beskow, it appears that capillary-saturated soils of the Reinheim-Blåhø type have a rate of water movement to a freezing surface, when, for example, the frost has penetrated about 0·5 m., of the order of 0·02 cm./hr.—0·2 cm./hr.

The rate of water liberation at thaw will probably fall within the same range. The rate of maximum upward water movement in the thawed soil is indicated by the permeability coefficient of the soil. At 0° C. this is of the order of 0·001 cm./hr.—1·0 cm./hr., *i.e.* it may be higher than the rate of water movement to the freezing surface, and similarly of the rate of liberation of water by thawing.

Furthermore, several factors indicate that the rate of maximum upward water movement through the already thawed soil is considerably greater than the permeability coefficient. These are: (a) the permeability coefficient is the flow under unit hydraulic gradient (*i.e.* where $\frac{\text{loss of head}}{\text{length of path of flow}} = 1$), whereas the hydraulic gradient would immediately be greater than this where any excess water over saturation point occurred [1]; (b) the temperature of the thawed soil is substantially above

[1] According to the Terzaghi consolidation theory, see K. Terzaghi, 'Theoretical soil mechanics,' 1943.

0° C.; (c) the thawed soil is in an extremely disturbed condition and has many cracks and discontinuities.

From all these considerations it would seem that in many cases, especially where large terraces are developed on slight slopes and the soil is capillary-saturated throughout most of the year, ice layer-melting does not represent a water increase which can by itself cause flow.

Reduction of shear strength following disturbance due to ice layer formation.—It is known that disturbance of the soil often results in a loss of strength.[1] The void ratio $\left(=\frac{\text{volume of voids}}{\text{volume of solids}}\right)$, and water content at the saturation point, are increased. The presence of discontinuities, both where ice layers have disappeared and at the thawed soil and ice boundaries, mean that the shearing strength of the soil is greatly reduced, and may render the soil liable to flow if the angle of slope is sufficiently steep. Determinations of the loss of shearing strength following ice layer formation and melting would be very difficult. The frontal banks of the large Reinheim-Blåhø terraces represent a local steepening of the slope to often 60°–90°. The fallen-out appearance of some frontal banks may represent slope failure due to this disturbance, but this occurs infrequently. Relative stability over many years is also indicated by the vegetation cover of the fronts in general. Although the ice layer distribution is different in the terrace fronts, this seems to indicate that in slopes so slight as that over the terrace surfaces (approximately 2°–15°) little movement can occur as a result of weakening of the soil by disturbance.

Terrace formation.—Whatever the causes of the solifluction, wherever there are changes in the rate of downslope movement there will be a corresponding tendency for soil to accumulate. In frost-susceptible soils, variations in frozen ground structure and frost-heave occur for various reasons and are important in determining the rate of movement. Local absence of vegetation results in more rapid freezing and less ice per unit volume, but a greater depth of frost penetration. Changes in the depth of the groundwater table, and in the nature of the soil, have similar effects. Such variations generally become more marked with successive years, as the gradual displacement or accumulation of the soil usually increases the effectiveness of the factors causing the variation. Angle of slope is, of course, also an important factor. If soil accumulation proceeds long enough a marked ridge or step will be formed on the surface, and this may be pushed forward by continued accumulation behind it, so that it moves over the vegetation at its foot. Eventually a distinct frontal bank will be formed. This may be built up so high by continued accumulation that it eventually collapses forward. Some such cycle of development is strongly indicated by the various forms and sizes of the frontal banks of the large terraces at Reinheim and Blåhø.

Causes of movement in solifluction forms not restricted to frost-susceptible soils

Many forms of solifluction found on steeper slopes occur, especially in Rondane, on soils that are not, or only slightly, frost-susceptible. These forms of solifluction (isolated terraces Plate 3, many small terraces Plate 4, or a mere wrinkling of the surface) are, nevertheless, due to the effects of snow, and excess water which in areas of non-frost-susceptible soil must be largely derived from snow meltwater. They are commonly associated with late-lying snow. As noted earlier, movements of up to 0·5 m. a year have been recorded in these types of solifluction. During most of the summer the soil is often relatively dry, so that the wet condition of the soil during the thaw represents a period of weakness. The effect of still unmelted snow is to load the steep slope so that the chance of movement is increased.

[1] Hvorslev, M. J., "Über die Festigkeitseigenschaften gestörter bindiger Böden" (with English summary), *Ingen-Vidensk. Skr. A.* Danmarks Naturvidenskapelige Samfund, Kopenhagen, 1937.

The formation of a single terrace under a late snow patch.—These effects are well illustrated in the formation of a single terrace under a late snow patch (*e.g.* Plate 3). The terrace is seen protruding from under the lower edge of the snow patch. The photograph was taken in Rondane and it is commonly observed there and verified by ground temperature measurements, that these snow patches melt substantially from the underside. The soil is entirely thawed while there is still a substantial snow patch present. Meltwater from the snow occurs in considerable quantity in the slope, percolating through the soil under, and downslope of the snow, and it also probably seeps upwards through the surface in the exposed parts of the terrace (Fig. 5a). The mass of unmelted snow probably restricts the surface drainage of the upper part of the slope, and certainly prevents evaporation.

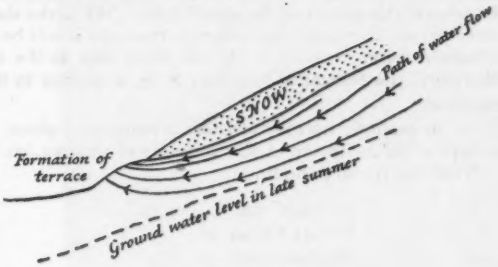


Figure 5a

The significance of these conditions becomes clearer on considering the mechanics of slopes. Mass movements can only occur by shearing of the soil. For cohesive soils the shearing strength (or resistance to shear) which must be overcome before shear can occur, is given [1] by

$$S = C + \bar{\sigma} \tan \phi$$

where C is a figure due to the cohesion of the soil, $\bar{\sigma}$ is the effective, or intergranular, pressure (*i.e.* the forces transmitted from grain to grain) on a plane parallel to the plane of shear, and ϕ is the angle of internal friction, of the soil in question.

The total stresses acting on a plane (see QQ in Fig. 5b) through a point in a slope, are considered as a direct stress σ, which is the normal component of force per unit area across the plane; and a shearing stress τ, which is the tangential or shearing component of force per unit area. If τ exceeds S (the shearing strength or resistance to shear) the soil shears along the plane and movement occurs. If no part of the stresses are carried by water pressure in the soil (*i.e.* if the soil is dry), $\sigma = \bar{\sigma}$, otherwise $\sigma = \bar{\sigma} + u$, where u is the pore-water pressure. The stresses on any plane parallel to a slope can be calculated in terms of the weight of soil above the plane. Although the planes of shear are not likely to be parallel to the slope and the stresses on them therefore, not determinable before movement has occurred, nevertheless the effect of snow and snow meltwater on the state of stress in the slope can be illustrated in a general way, by considering stresses on a plane parallel to the slope.

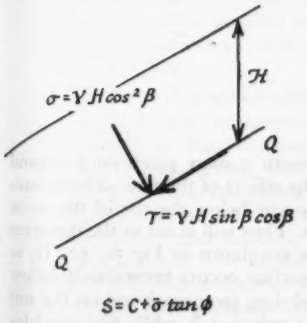


Figure 5b

For an infinite slope of soil of entirely uniform conditions it is known that for a point on a plane parallel to the surface at a vertical depth H (see Fig. 5b):

$$\tau = \gamma H \sin \beta \cos \beta$$
$$\sigma = \gamma H \cos^2 \beta = \bar{\sigma} + u$$

[1] See, for example, D. W. Taylor, 'Fundamentals of soil mechanics.' Wiley, 1948.

where γ is the unit weight of soil, β is the angle of slope, and u is the pore-water pressure.

$\sigma=\bar{\sigma}$ for a dry slope, because $u=0$ (as noted above). The effect of saturation by snow meltwater will be to introduce a water pressure. At the same time γ will increase because of the weight of the added water. While the shearing stress τ (and the direct stress σ) are increased, the effective pressure $\bar{\sigma}$ will be decreased because of the introduced water pressure u. At the same time as the shearing stress τ is increased, therefore, the resistance to shear, S, is, according to the expression $S=C+\bar{\sigma}\tan\phi$, reduced.[1]

As an example we may consider a point on a plane, at vertical depth $H=1$ m. in a slope of 30°, with soil of unit weight γ of 1500 kg./cu. m.

Then for the dry condition:

$$\tau=1500\times\sin 30^\circ\cos 30^\circ$$
$$\tau=645 \text{ kg./sq. m.}$$

and
$$\sigma=1500\times\cos^2 30^\circ$$
$$\sigma=1125 \text{ kg./sq. m.}$$

For the saturated condition, the pore ratio $\left(=\dfrac{\text{volume of pores}}{\text{volume of soil}}\right)$ must be taken into account, and can be given the value of 0·4. The water pressure u may be taken as: unit weight of water $\times H=1000$ kg./sq. m. (this figure may be substantially different for natural slopes, as shown below). The unit weight of soil γ, is now $1500+0{\cdot}4\,(1000)=1900$ kg./cu. m.

Then
$$\tau=1900\times\sin 30^\circ\cos 30^\circ$$
$$\tau=822 \text{ kg./sq. m.}$$

and
$$\sigma=1900\times\cos^2 30^\circ$$
$$\sigma=1423 \text{ kg./sq. m.}$$

but
$$\bar{\sigma}=(1423-1000) \text{ kg./sq. m.}=423 \text{ kg./sq. m.}$$

Comparing the ratios of shearing stress to effective pressure we find for the dry state:

$$\frac{\tau}{\sigma}=\frac{645}{1125}=0{\cdot}57$$

and for the wet state:

$$\frac{\tau}{\bar{\sigma}}=\frac{822}{423}=1{\cdot}94$$

The pore-water pressure at different points beneath a snow patch on a natural slope will vary, and it is not altogether clear what the effects of the flow of meltwater will be. High pore-water pressures will probably occur below the toe of the snow patch but these must dissipate to zero at the surface. Flow will occur in the direction of the hydraulic gradient, and suggested flow lines are shown in Fig 5a, 5c. If, as seems probable, seepage towards and through the surface occurs immediately below the snow patch, then the water will exert an upward drag (seepage force) on the soil particles there. This will have the effect of further reducing $\bar{\sigma}$, while fine particles will be washed out. Internal piping (the development of enlarged flow channels) may occur in this part of the slope, followed by some collapse of the soil structure. The paths of flow and the rate of flow will depend, however, on the permeability of the soil and the rate of melting of the snow, and much of the hydrostatic head may be lost as the water flows from the higher parts of the slope. In the latter case, the water must be considered as exerting compressive forces tending to increase τ. In either case the flow of the water increases the tendency to soil movement. In the case of late snow patches in slight hollows in a slope, the water will assume more importance,

[1] Both C and ϕ also may have substantially lower values under saturation conditions.

as the flow will concentrate towards the lower part of the slope as shown in Figure 5c. The weight of the still unmelted snow also obviously increases the likelihood of soil movements occurring slightly downslope from it. There are therefore several factors operating both to reduce the shearing strength of the soil, and to increase the shearing stress.

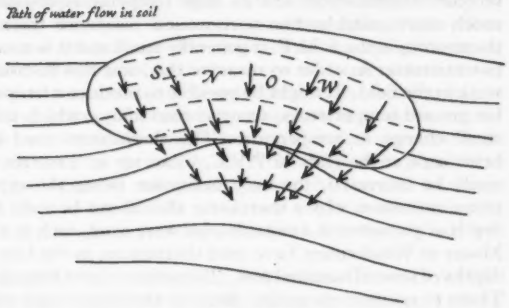


Figure 5c

Although it has been convenient to leave this consideration of the mechanics of a particular form of solifluction until the end of this paper, an approach along these lines is indicated in all detailed studies of solifluction. Eventually it may prove possible to produce slope analyses of the type now used by engineers in studies of the failure of earth dams, levees or other soil masses in which seepage forces must be considered, for many cases of solifluction. At present the difficulties of determination of shear strength in morainic soils are very great. Relative studies of solifluction, with consideration of those factors especially operating when soil movements are found to occur, will give strong indications of its likely causes.

DISCUSSION

Afternoon Meeting, 26 March 1956

Before the paper the CHAIRMAN (Professor J. A. STEERS) said: Solifluction is an interesting and wide problem, and Mr. Williams is concerned chiefly with glacial phenomena in the mountains of Norway, where he has studied areas affected by it. His approach to the problem is new, because he had applied actual measurements. That is a considerable advance, and as in other branches of geomorphology, promises well for the future.

Mr. Williams then read his paper

Mr. ERIC SMITH (Department of Metallurgy, Cambridge): I should like to add a few details to Mr. Williams' description of the apparatus used in the determination of temperatures, and the attempts to determine movement of soil in the terraces. Firstly the thermistor, which seems to represent a great advance on anything used so far in soil thermometry. The two main advantages of the instrument are its sensitivity and flexibility. The upper limit of its range is about 200° C. and it has a resistance of zero at that temperature. The resistance increases as the temperature falls until it is about 4000 ohms at 0° C. The temperature-resistance curve is approximately logarithmic which is shown by the fact that the curve of logarithm of resistance against temperature is nearly straight. For calibration of the instrument it is best to plot this latter curve since it is easier to draw what is nearly a straight line than a logarithmic curve. At 0° C. the resistance is changing at approximately 20 ohms per °C. It is easy, with a comparatively rough instrument, to measure to 5 ohms in 4000; with a good instrument it is possible to measure to better than 1 ohm and consequently to obtain temperatures to an accuracy greater than 0·1° C. The Wheatestone's bridge used in Norway gave a direct reading of the resistance which meant that it had to be converted to its logarithm before the temperature could be found from the calibration chart. It is hoped that a Callender and Griffith bridge, which measures percentage change in resistance as the temperature changes, will in

conjunction with this instrument give an approximately straight line of percentage change against temperature in the region of ±10° C. so that direct reading will be possible. The thermistor is much more flexible than either the thermocouple or mercury thermometer and its large temperature/resistance change at 0° C. makes it much more suitable than wire-wound resistance thermometers. In the case of the thermocouple the E.M.F. is generally small and it is necessary to have a very sensitive potentiometer in order to measure this, and this instrument is large and difficult to work in the field. It might be possible to produce a temperature-measuring instrument for ground temperatures, using certain alloys, which will give a large E.M.F. with a small change in temperature. The thermistors used in Norway were mounted in brass caps at the ends of P.V.C. tubes up to 2 metres in length. The length could easily be increased, the only limitation being the type of mounting used. There seems no reason why a thermistor should not be used to measure temperatures at a depth of 50 metres if a suitable pipe were used, such as a hollow borer. Mortimer and Moore at Windermere have used thermistors in the lake on the end of a long cable at depths of several hundred feet. Thermistors have been lowered down holes in glaciers. There is no need to mount them in absolutely rigid tubes, but our tubes could be pushed into soft earth without boring. The maximum safe continuous power dissipation to prevent overheating and damage of the thermo-element is about 10 milliwatt. At Reinheim the power used was about 2 milliwatt with a 4·5-volt dry battery. The current was only flowing when the temperature reading was being taken. When the 4·5-volt battery was replaced by one of 1·5 volts the power dissipation was about 0·2 milliwatt and it was found that the smaller heating effect in the bead gave rise to a different resistance for a given temperature under static conditions. This suggests a possible use for thermistors to measure ground water flow. The temperature of the ground water would be measured using 1·5 volts when the heat generated in the bead is small and the resistance is almost independent of rate of conduction of heat away from the bead. The temperature of the bead would then be raised by application of a higher voltage and a second reading taken. The greater the rate of heat conduction from the bead, the higher will be the resistance—which falls as the bead heats up—and it may be possible to correlate this with rate of flow of ground water. The mounting of the thermistor would have to be modified in that the bead would have to be in contact with the water to obtain maximum sensitivity, instead of being fixed into the brass cap. One disadvantage of thermistors is that there may be a slight drift in the resistance.

Although this does not alter the sensitivity, it alters the actual reading of the temperature for a given resistance, so that it is necessary to recalibrate periodically. This is not a serious matter except that it takes time. In any case, the thermistors appear to settle down after some time. Mortimer and Moore found that after about a year's use the resistance seemed to have become stabilized. Certainly thermistors represent a most effective method of ground temperature measurement.

The strain gauges were rather less successful than the thermistors, mainly because of insulation troubles. These seem to have been overcome now by the use of cold-setting plastics, but the binding and insulating is both costly and time-consuming, added to which the insulating cover of plastic tends to produce some mechanical hysteresis when the strain on the strip is relaxed. A strip of plastic does not bend back elastically as the stress is relaxed. However, when insulating problems have been fully solved, the use of strain gauges attached to metal strips should yield some useful information. The strips will show up any differential movement in soil layers, provided that it does not take place on a single plane; that is, that there is no pronounced shear plane. The strip can bend both ways—*i.e.* in a letter S—and will show this on the gauges. The actual amount of deformation will be difficult to calculate, and the strip has to be calibrated. The reason for this is the thick covering of insulating material. Also under long stresses and much deformation the strip will tend to stay bent, but the fact that the strip is bent in one direction or another should be easy to

determine. One use to which strain gauge strips might be put is in glaciology; it would be easy to bore a way into the glacier, push the strain gauge strip down and let the strip freeze in. This would be an easier method of consolidating the strip than any of the methods we can apply in soil. The length of the strip is limited only by the number of strain gauges, since the wire-leads from more than eight gauges—four to each point since there are two gauges at each point—become too difficult to handle. Another possible use for this sort of instrument would be as a detector of avalanches, or mud banks which begin to move slowly or by very small amounts before the final movement takes place. It might be possible to bury some of the strain gauge strips in the mass and detect movement on a small scale before the large movement occurs by which time it is too late to do anything. If it were possible to detect when some movement had begun to take place it might be possible to detect when the actual main flow was likely to occur. The bending of the strip could be noted and sudden shifts detected. Clearly much development work is still needed, but there are great possibilities.

Mr. A. N. SCHOFIELD (Department of Engineering, Cambridge University): Mr. Williams was quite right to direct attention towards the soil mechanics aspect of the problem when he drew the velocity profile. However this profile is derived, even if by an upward lift and falling down under gravity, it does imply that a box of soil that originally had right-angle corners is twisted over into the shape of a parallelogram. If the soil is thus sheared it must be because the shear stresses cause shear failure in the soil. The figures that are given for the heave are such that a considerable reduction of density must occur, and such a heave would result in a great weakening of the soil.

The second point I would like to make is that possibly there may be records of old movements in aerial photographs. I do not know to what extent aerial photographs of the area were taken in the past, but if they were available and a photograph of more recent date could be compared with them it is possible that movements could be detected that could be attributed to solifluction.

Dr. CHARLES SWITHINBANK (Scott Polar Research Institute, Cambridge): I would like to congratulate Mr. Williams on his very lucid explanation of a difficult subject. There is an application of solifluction studies which interests me. If you build a road or a house on a moving terrace, how do you prevent the whole structure being carried away? There appear to be two possible ways. In the first, the active layer is removed and foundations are built on permafrost or upon bedrock. A disadvantage is that the active layer is prevented from moving and might endanger the structure by accumulating against it. Alternatively, a house could be constructed on stilts like a lake dwelling, allowing the active layer to pass beneath.

Mr. P. J. WILLIAMS: Mr. Schofield made a point about the creep effect, namely, that it implies shear, and that shear implies shear stresses causing failure. That was a point I tried to make. It is possible that the creep only occurs if the soil is in an unstable equilibrium due to one of the causes I mentioned—excess water, disturbance of soil and so forth. If the soil is thus unstable, then it only requires some tiny extra force to make the shear. Where there is a heave effect it induces this component of force, downslope at thawing. If the soil were to sink back to its original place you would need a component of force up the slope. I think the movement of the soil upwards perpendicular to the surface does imply a component of force which represents additional stress, so that if the soil is unstable maximum creep may occur (although perhaps combined with movement due to other causes).

Aerial photography of these features is used largely to detect areas in which solifluction occurs. We also use photographic methods (from the ground) substantially, for recording annual movements. I have not mentioned that much of the work done by us on our expeditions has been on another type of solifluction—that occurring on level ground where there are stony earth circles. There we have taken a large number of photographs and are recording very interesting movements each year. It is easy to see the amount of movement occurring each year in stony earth circles. It is not so

easy to discern that with solifluction terraces. There is also the question of finding the same place again, of having fixed markings, and if the whole of the surface is moving down the slope one does not know where to begin.

Dr. Swithinbank mentioned the practical implications of solifluction terraces. Solifluction must clearly be taken into account when one is building roads. The nearest I have come to movement of soil due to solifluction terraces and its effect on building occurred about two years ago, when a tourist hut put up by the Norwegian Tourist Association went down one side because the soil moved away from underneath it. There are other instances. Small wooden settlements in Norway are reported as moving downhill annually, and this has happened for so long that the inhabitants are no longer surprised to find each spring that they have been moved. The practical effects of frost heave and so forth are very serious. One method of dealing with the problem is to dig out the soil to the depth to which the frost penetrates and to replace it by non-frost susceptible material, so that there will not be dangerous heaves. Or one may do as the railways do and put in insulating layers, and layers of heat-absorbing material, the natural soil being replaced by a mixture of wet peat and coarse ballast to a depth of perhaps 80 centimetres or so. One certainly must take steps to prevent any sort of frost-heave if a house is to be built. That cannot be expected to be heaved up and down each year and remain unaffected.

The CHAIRMAN: I think Mr. Williams has made his case. When I discussed the problems of solifluction in my lectures some years ago, it fortunately did not include mathematics; I am almost sorry to see that it now does. Mr. Williams has demonstrated the importance of the subject, not only from the geomorphological point of view, but also from a practical one, and has shown how it links with ecology, as so many geomorphological problems do. It also is connected with building research and even metallurgy. Mr. Williams has rendered useful service to his subject by investigating problems which are of value not only to geographers but to many other workers also. In your name I thank him very much for his lecture, and wish him every success in the continuation of his work.

COASTAL DUNE LAKES AS EXEMPLIFIED FROM KING ISLAND, TASMANIA

J. N. JENNINGS

IT IS USEFUL to define types of land forms and to classify them genetically, for we thus provide ourselves with a convenient framework of concepts against which the geomorphological details of particular regions can be matched and which brings out the relationship and comparative importance of the various operative factors. Nevertheless it is true that simple types which fall unequivocally into the single categories of the textbooks are rarities in the field; our classificatory systems often conceal, or at least scarcely hint at, the variety of character and complexity of origin of the entities with which we grapple in nature. During a recent study of the coastal geomorphology of King Island, Tasmania, this observation was emphatically brought home to the writer by the heterogeneity of the numerous coastal dune lakes of the island. Since the enquiry was mainly directed at questions of changes in the relative level of land and sea, no detailed investigations of these lakes were made and the lack of soundings is particularly felt; however, the examples discussed here may serve to illustrate the general point with which this brief account begins.

King Island (Fig. 1) consists essentially of a faulted and tilted peneplain developed on Precambrian metamorphics, Cambrian volcanics and tillites, and Palaeozoic granites (Debenham, 1910; Waterhouse, 1915; Carey, 1946). The old erosion surface stands highest in the south-east at altitudes of 300 to 550 feet but declines westwards and northwards so that along a good deal of the coast the foundation of country rock lies not much above, and in parts below, sea level. Extensive development of coastal dunes has occurred and around much of the periphery of the island the dunes form a rim rising higher than the country immediately inland. In this context it is not surprising to find innumerable swamps, lakes and lagoons [1] scattered through the island.

The dunes fall into different systems of varying age and composition, but for our present purposes it will be sufficient to distinguish two main groups—the New and the Old Dunes.

All the New Dunes, though including several lesser groups of successive age down to dunes now forming, retain the sharp crests and steep slopes of their vigorous original forms, which are in general unmodified, though practically entirely fixed by vegetation. As a result of grazing and burning, fresh blowouts occur throughout the New Dunes. In composition, there is a range from dunes virtually entirely of quartz sand to others which are almost completely of shell sand. On the west coast, the New Dunes all have a high proportion of shell sand and there has been much deposition of secondary calcite to produce aeolianite (calcarenite) which is exposed to blowouts and cliffs behind the shore. The calcium carbonate content of the dunes remains high eastward to Lavinia Point on the north coast and round to Grassy on the south; but the east coast dunes are very largely of quartz sand, a fact reflected in their common cover of bracken. Nevertheless podsols, though developing quickly, are still shallow even on these quartz dunes, and the main body of the quartz sand remains yellow in colour from the iron-staining of the grains. Leached grey-white sand of the A2 horizon is only a foot or two deep and the humus pan no more than a few inches thick. Where the relationship of the New Dunes to emerged strandlines can be established, it is seen that they are associated with a former sea level stand

[1] Readers in the United Kingdom should be warned that in Australia "lagoon" is used not only for stretches of coastal water isolated completely or partially from the sea by littoral constructional features, but also more loosely to apply to almost any lake, though more commonly to those shallow, small and intermittent in nature.

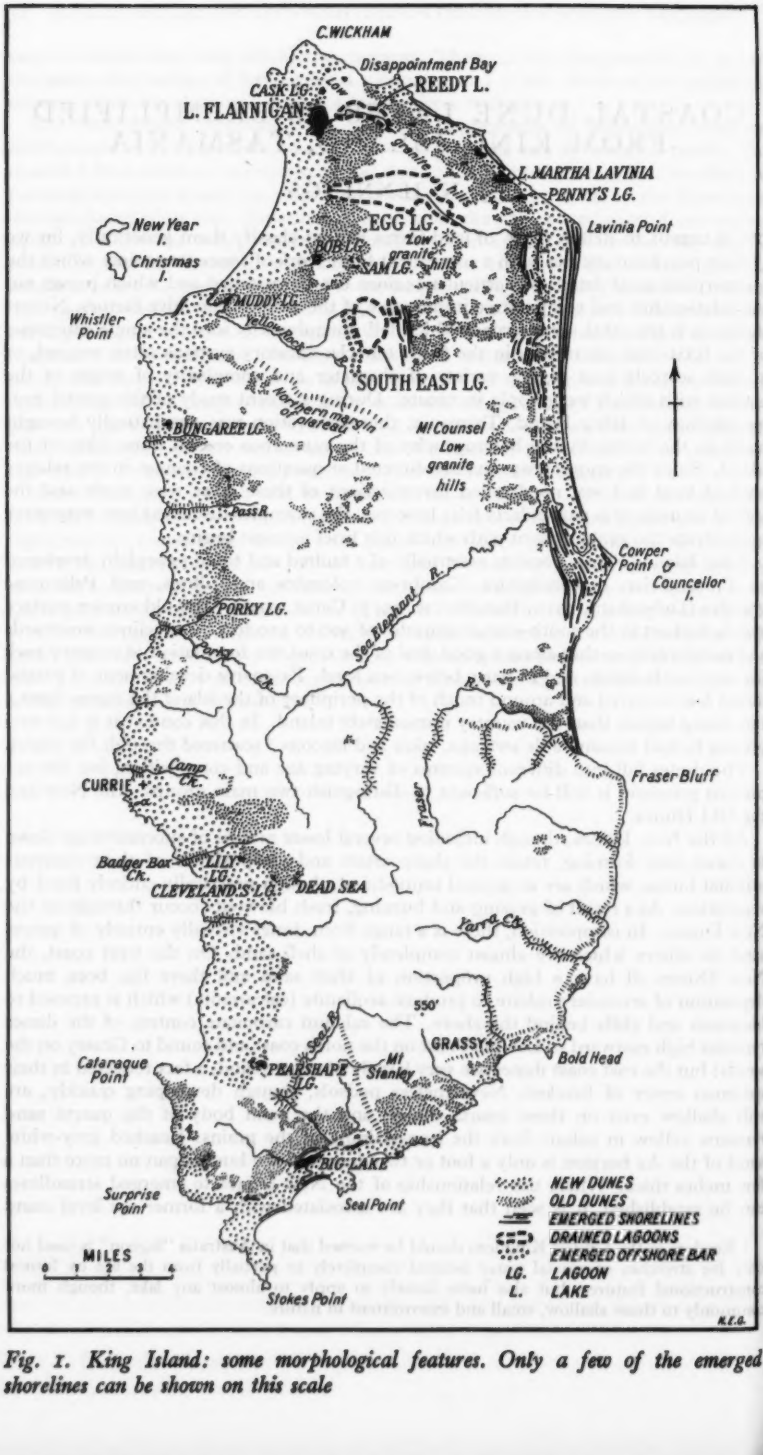


Fig. 1. King Island: some morphological features. Only a few of the emerged shorelines can be shown on this scale

about 10 feet above mean sea level although they continued to form after its emergence. This 10-foot stand is interpreted as eustatic and is the one correlated by a number of workers in Australia with the Post-glacial thermal maximum (Fairbridge, 1947–48; Gill, 1947).

These Old Dunes have lost through various processes of degradation much of their characteristic detail of sculpture and much of their vigour of relief, though in some parts it remains quite pronounced. Smooth swells and rounded whaleback ridges are most common, but many parabolic dune patterns can still be identified both on the ground and in the air photographs. They are all fixed by vegetation and blowouts do not develop in them, even at points broken up drastically by cattle-tracks. On the east, north and south coasts, the Old Dunes consist of deeply leached white quartz sand, in places tens of feet thick, and beneath that there is "coffee-rock," a red brown or dark brown, humus-bound sandrock, which can also be many feet thick. We have here surely the profile of an extremely deep podsol. On the west coast, there are some areas of Old Dunes of exactly the same nature but others of quite distinct composition. They are of cream calcareous sand and aeolianite beneath a red-brown soil of Yambacoona Sand type (Stephens & Hosking, 1932). This Yambacoona Sand is coarse, with a lime content generally low but in places substantial. In relative position and topographic character there is nothing to suggest that these two types of composition of the Old Dunes of the west coast correspond with two systems of markedly different age. The explanation of their difference is problematic but as the possible solutions of the problem do not bear on the theme of this paper they will not be discussed. On the east coast the Old Dunes can be seen to have been formed mainly at high sea level stands of 30–45 feet, while in one area behind the west coast they have been constructed in the rear of old shorelines, which rise as high as 67 feet, though this may be partly due to a local tidal effect. Lesser Old Dune development took place as sea level was falling from these high levels to levels approximately to the present. As to the age of these high sea level stands and the associated dunes, one cannot say more at present than that they are probably Upper Pleistocene.

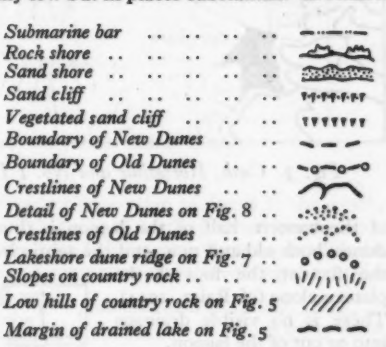

Submarine bar
Rock shore
Sand shore
Sand cliff
Vegetated sand cliff
Boundary of New Dunes
Boundary of Old Dunes
Crestlines of New Dunes
Detail of New Dunes on Fig. 8
Crestlines of Old Dunes
Lakeshore dune ridge on Fig. 7
Slopes on country rock
Low hills of country rock on Fig. 5
Margin of drained lake on Fig. 5

Fig. 2. Key to symbols on Figs. 3–5 and 7–10

Of the lakes due to the development of coastal dunes, the type most commonly discussed in the text-books (*e.g.* Collet, 1925; Cotton, 1948) is that in which the dunes have advanced inland to block a coastward-draining river valley. They are typically triangular in plan with their apex pointing up the valley and are deepest near the dune wall. In King Island this type is not well represented; the major streams have successfully maintained their flow through the encroaching dune belts, perhaps because of their steady regime: this combines with the building up of the dunes to produce narrow, steep-walled valleys through the coastal dune belt, as much as 2 miles long and more than 200 feet deep in places. Those of the Ettrick River, the Pass River and the Badger Box Creek are the finest and warrant the name of "gorge" which has been applied to them.

Examples of lakes which approximate to the simple dune barrage type are furnished by two small lagoons near the northern end of the island, where the New Dunes have advanced up the flanks of low rounded granite hills and impounded Horseshoe Bend and Cask Lagoons in broad hollows rather than well-defined valleys (Fig. 3). There is little drainage into either and they have no surface outlets but seep

into the New Dunes. Nearby is "No. 1" Lagoon, which occupies a shallow rounded hollow near the summit of one of these subdued granite hills. Here the barrage appears to consist of a very thin and uniform spread of Old Dune sand, which has lost all dune form, if it ever had any. There is a small flood outlet at the eastern end of this sheet of sand a few feet thick, which constitutes the straight northern shore of the lake. The altitudes of this group of lakes were not measured [1] but they must lie between 60 and 100 feet above sea level, Cask being the lowest and "No 1" the highest.

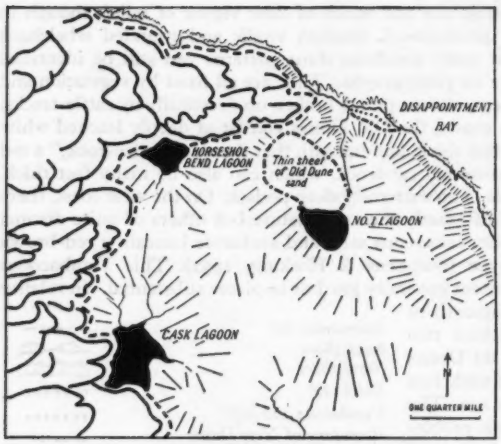


Fig. 3. Cask, Horseshoe and No. 1 Lagoons

Bungaree Lagoon (Fig. 4) falls into this same category of dune barrage lake but has an interesting departure from the normal triangular plan. Here the New Dunes did not advance as far inland as the Old Dunes but blocked a gap between two lobes of the older system. Beyond lies a flat area, followed by a very gradual rise of the plateau. The plan of the western half of the lagoon is thus strictly governed by the pattern of the dunes, both old and new, and the semi-circular eastern part is due to wave action in the flat at the foot of the plateau slope (*cf.* Raisz, 1934). There is no visible drainage into or out of the lagoon.

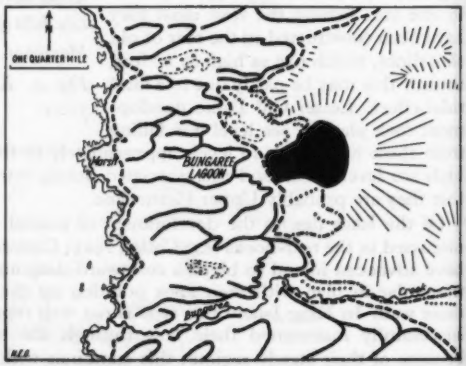


Fig. 4. Bungaree Lagoon

There are other small lakes of comparatively simple barrage type on the island, but with many, particularly the larger ones, the situation becomes more complex. Let us consider the case of Lake Flannigan (Fig. 5). the largest extant lake on the island, just over a mile in meridional length and about three-quarters of a mile in maximum width, lying at about 50 feet above sea level. The deepest water lies to the west where the lake is very obviously impounded by the steep and high wall of the New Dunes, through which it drains underground to a series of resurgences on the coast at a point locally known as "The Springs." But this is not the full story because only on the

[1] The only maps of King Island are cadastral plans on which there are no altitudes or other topographical features. To offset this, good air photo cover is available. Aneroid determinations and some lines of levels were made by the writer but in the main these were to serve other problems than the present one.

north-east does the solid foundation of the island rise up to form part of the inland slopes of the enclosing basin. The southern flank is provided by a deep extension inland of Old Dunes of the calcareous Yambacoona Sand variety. Reedy Lake, a shallow lagoon, formerly extended eastwards of Lake Flannigan between the low

Fig. 5. Lake Flannigan and the former Reedy Lake

granite hills to the north and this subdued earlier generation of dunes to the south. At its eastern end it was in part enclosed by Old Dunes of deeply leached quartz sand, which moved in from the north coast of the island. The containing basin of Lake Flannigan and the former Reedy Lake is thus a composite affair, involving the inland advance of dunes from two coasts and at two quite different times to complete the framework.

The shape of Lake Flannigan is also of some interest. The western and north shores follow strictly the lobate forward outline of a series of parabolic dunes. The southern part of the east shore reflects less closely the sinuosity of the tails and central hollows of the parabolic dunes of the older complex. In the 1/31,680 Lands Department plan of the island, the lake shore, surveyed spasmodically between 1896 and 1919, is here much more indented and corresponds much more closely to the dune relief than in the air photos taken in 1946 (Figure 6); the change is at least in some measure due to wave constructional work. The northern part of the east shore illustrates very definitely the effect of wave work; here is an arcuate shore of which the longer straighter part is at right angles to the direction of approach of the most frequent storm winds from the west. It is consequently also at right angles to the axes of the parabolic dunes which govern the form of the opposite shore. This smooth shore of erosion is prolonged southwards by a tiny spit extending partway across the mouth of the bay which interrupts this eastern shore; into this bay, which has contracted between the 1896–

Fig. 6. Changes in the shore-line of Lake Flannigan

1919 cadastral survey and 1946, enters some of the drainage from the area of the former Reedy Lake.

How much of the drained Egg Lagoon (Fig. 1) was ti-tree swamp and how much was shallow open water at the time of settlement of the island it is not possible to say precisely. However, there is here the same overall, though less clearly defined, arrangement of genetic features as in the case just discussed. The floor of Egg Lagoon lies about 50 feet above sea level and occupies part of a low, flat plain which is underlain by estuarine-marine silts and clays; these were laid down at the time of the higher sea levels associated with the formation of the Old Dune system. This plain is in fact largely rimmed by Old Dunes encroaching from both west and east, though there are also low granite hills on the northeast and southeast quarters. But in addition the western end of the lagoon, narrowing in the re-entrant between two lobate areas of Old Dune, was held up by the abrupt inner margin of the New Dunes. The western end of the drained lagoon floor is today much the wettest part of it and apparently the lagoon originally drained underground through these New Dunes (Stephens & Hosking, 1932). The artificial outfall leads indirectly through an elongated swamp "The Nook" to the Sea Elephant River on the east coast. Nevertheless we cannot be certain that Egg Lagoon only came into existence with the advance of the New Dunes to close a gap in the Old Dunes. Elsewhere on the island it is certain that Old Dunes underlie New Dunes and so it is possible that the girdle of dunes was complete here on the west at the earlier phase; there may have been a freshwater lagoon dating from the time of formation of the Old Dunes or from the time of the emergence of the estuarine plain and its associated dune rim. It is unfortunate that this point is not easy of solution because from Egg Lagoon have come two of the King Island finds of giant marsupials. A skeleton of *Nototherium victoriae* Owen (Scott, 1912) was found practically at the surface at the western end (R. Greaves, personal communication) and teeth and jawbones of a *Diprotodon* species, somewhat scattered, came from the clay underlying the swamp peats towards the eastern end (Keble, 1945). Both finds are likely to belong to the lake phase rather than to the preceding estuarine one and were we able to unravel the genetic history of the freshwater lagoon it might be possible to delimit more closely the range in time of this extinct fauna.

Further south again lies another drained lagoon of some size, South East Lagoon (Fig. 1), across which a levelled line of shallow hand bores has been put down with a Hiller-type peat-borer. The general pattern is at first sight so like those of Lake Flannigan and Egg Lagoon that one might be tempted to place it in the same category, which might be termed a complex dune barrage lake type. South East Lagoon, again at a height of just over 50 feet above sea level, occupied the south-eastern part of the same plain of estuarine-marine accumulation as that on which Egg Lagoon developed. To the south rises the northern margin of the main plateau of King Island, to the east lies a broad belt of Old Dunes, which largely blew in from the east coast. Directly north, between it and Egg Lagoon, are very slightly higher and sandier parts of the plain, while to the north-west are Old Dunes from the west coast. Westwards the plain falls gently to the coastal dunes, mainly New but backed in places by Old Dunes, and broken by the estuary of the Yellow Rock River into which the drains of South East Lagoon empty. The broad context then is the same, but it is quite clear that the dunes to the west did not contain the former shallow lake. The proximate barrier on this flank is merely a long narrow sand ridge, in an arc concave to the west and only 5–6 feet above the flat floor of South East Lagoon. It has a long, gradual slope to the west and a more abrupt one facing the lake floor, and fails to link with the rising ground on the solid to the south or with the Old Dunes to the north. So it is to be interpreted as a former off-shore bar (barrier-island in Shephard's terminology (Shepard, 1952)), rather than as a midbay bar, in the estuarine embayment which formerly occupied this area. When the area emerged, it was this wave-built, rather than wind-built, feature, which completed the shallow basin of the freshwater lake on the west.

Where there are no shingle ridges to render the picture clear, it is usually by no means easy to estimate the relative importance of the two processes just mentioned; indeed they are so much accompaniments of each other and often so mutually reinforcing that it is at times pointless to pursue the distinction.[1] This can be illustrated if we turn to the southern end of the island. North of Stokes Point (Fig. 7), a chain of five small lagoons is arranged along the inland margin of the New Dunes. The lagoons are mainly elongated along this margin but the two easternmost fill recesses in the dune wall. The lagoons are highest in the west, draining successively, but in places indistinctly through swamps, to the easternmost, which is a little over 30 feet above sea level. The westernmost pair lies quite simply between the New Dunes and the steeply sloping southern end of the plateau. Farther east the plateau slopes more gradually and has an eastward component; on this slope are plastered subdued dunes of the older system. They are thin on the whole, however, and outcrops of solid

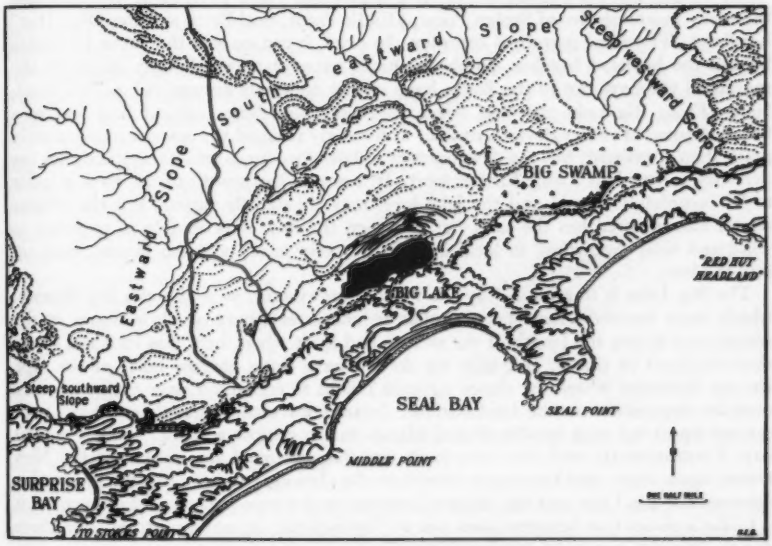


Fig. 7. Big Lake and neighbouring lagoons

show that essentially the other lagoons also lie between the New Dune wall and the plateau slope. The drainage from the easternmost of the chain is probably mainly by seepage into the New Dunes, though there is very poor and indirect connection through field drains winding amongst low ridges of rock and Old Dunes to the Big Lake.

Behind the Big Lake and the Big Swamp, the plateau retreats northwards but it swings southwards again on the east to form a westward-facing scarp overlooking a broad embayment. Within this embayment there are four belts of country trending south-west to north-east:

(a) On the north there is the plateau slope, generally gradual and drained south-eastwards by the Seal River and its tributaries, which are moderately incised.

(b) Covering the lower part of this slope there is a belt of Old Dunes of subdued and somewhat interdeterminate relief but consisting largely of parallel low ridges; these trend south-west–north-east and are progressively lower to the south-east.

[1] J. Tricart (1951) discusses an instance where wind and wave action are in conflict.

Their original character is by no means clear but they have on the whole the appearance of degraded foredunes. The depressions or swales between them contain swamps and streams which join the main south-eastwards drainage at right angles.

(c) In front is the depression occupied by the interconnected Big Swamp and Big Lake, both no more than a few feet above mean sea level. The Big Swamp, into which the Seal River and its major tributary debouch, consists mainly of ti-tree swamp, with standing water in wet weather, and here and there of permanent but very shallow water. The Big Lake is a permanent stretch of open water, three-quarters by a quarter of a mile, with encroaching reedswamp on its margins. On its northern side is a level plain which carries a series of very low parallel sand ridges, not more than a foot or two in height; these are beach ridges testifying to an impressive diminution of the Big Lake by wave construction with little change in lake level during the process.

(d) Finally there is a broad belt of New Dunes half a mile or more in width, linking the rocky promontories of Stokes Point, Middle Point, Seal Point and the "Red Hut" headland. The dune pattern is complex. In brief, it can be said that from foredunes behind the bayhead beaches, parabolic dunes have advanced directly inland in the middle of the bays but to the flanks have swung obliquely around behind the headlands. From Big Lake the Seal River penetrates the dunes behind Seal Bay in a broad channel of rather devious course. It formerly reached the sea at a more easterly point than at present, but the development of later foredunes and parabolic dunes has deflected it over half a mile further west. In summer the mouth of the river is liable to be completely barred and the lake level may be slightly raised. But the greater winter run-off breaches the sand bar and then the flow is reversible in response to wind and tide. According to local information kelp is on occasion floated right up into the lake.

The Big Lake is impounded by the New Dune system, as is also the Big Swamp, which must formerly have been similar in character (there are low dunes at the eastern end facing the length of the swamp and built when there was lake and sandy shore in front of them). But here we do not have dune barrage lakes of the type already discussed where the dunes advance inland to embank a river valley or more complex depression on the land surface. Instead wave-constructed bars have been thrown up to link rock headlands and islands and to enclose a former shallow coastal bay. Concomitantly with the wave-built bars has occurred the growth of the New Dunes upon them, and these now constitute the obvious barrage. But the distinction between the Big Lake and the chain of lagoons to the west is clear and important; it is Collet's distinction between lakes due to "barrage par un cordon littoral" and those due to "barrage par des dunes maritimes."

Let us now consider other types of lakes due to wind action wherein the whole basin, more or less, is surrounded by sand and the genesis of the lake does not depend on the topography of the country rocks. The irregular, disorganized relief within dune belts is due to the combined action of deflation and deposition by the wind; thus the axial hollow of the parabolic dune, a most favourable locus for lake formation, is the product both of removal of material in the blowout (Windkühle, Ger.; caoudeyre, Fr.) and of accumulation in the advancing rim (Verjüngungswall, Ger.). Many small lakes and swamps in King Island occupy the axial hollows of parabolic dunes and the following discussion of these has the object of showing that further factors may enter into their formation than those suggested so far.

If deflation proceeds to such an extent that little or no sand remains in the floor of the axial hollow so that the impervious rock floor is exposed or but thinly covered, a lake may readily develop there. This seems to be the case in the New Dunes just south of the main township of Currie where a shallow intermittent lakelet some 400 by 40 yards occupies the axis of a parabolic dune, which is elongated WSW–ENE under the influence of the dominant storm winds of the west coast (Fig. 8, α on Fig. 1). Outcrops show that the floor of this depression is practically on the

solid. In this instance deflation seems the dominant element in the process of formation.[1]

In comparison with this example from the seaward margin of the New Dunes near Currie we may place an instance from the inland margin of the Old Dunes of the west coast at an altitude of about 340 feet (Fig. 9). Behind the outermost wave of parabolic dunes we find the "Dead Sea" and another small lake occupying neighbouring axial hollows. They are fairly compact in form since they occupy only the forward part of the hollows, the rest being in swamp. This forward position is in turn probably due to the fact that the dunes here were advancing slightly downhill into the drainage basin of the upper Ettrick River and so the forward parts of the axial hollows might easily be the deepest. The dunes here were thinning out in their advance and no great amount of deflation was necessary to keep the central floor fairly clear of sand and near to the impervious floor.

Nevertheless there are other occurrences where the factor of accumulation is dominant, rather than deflation, and raises an interesting issue. Thus east of South East Lagoon there is a lakelet (β on Fig. 1) in a parabolic dune hollow, which sits very high amongst one of the highest dune masses in this area. It is clear that there must be a considerable thickness of sand beneath this water body, which has furthermore very little possible catchment area by underground percolation or other means. Yet local information singled this lagoon out as the most permanent in the area, being rarely if ever known to dry up. Beside this fact must be set a more significant and more general observation arising from the distribution of lakes and swamps in the island in relation to the different dune systems. They are few within the New Dunes, whether these are calcareous in composition or not, and this despite the fact that enclosed depressions are at least as common in this system as in the older dunes. In proportion to total area, lakes are more numerous in the Old Dunes of calcareous type than in the New Dunes, but the highest frequency is found in the Old Dunes of quartz sand. It is true that these latter are often of slight thickness and that some of them are little removed from sea level, both factors favourable to the intersection of the dune hollows with the watertable. Nevertheless it is thought that a major factor, possibly the main factor, responsible for this high frequency is the development of an impermeable or but slightly permeable layer of "coffee-rock," humus-bound sand, through the pedological processes of podsolization. This has not had time as yet to become effective in swamp and lake formation in the New Dunes of quartz composition but has done so in Old Dunes of this nature. Though the humus pan is often at considerable depth beneath the Old Dunes, it is least so beneath the dune hollows and must tend to raise the watertable. Though they do not discuss the general problem in their account of the soils of King Island, Stephens and Hosking (1932) do incidentally attribute the existence of certain small high-lying lagoons in the "fernbanks," *i.e.* quartz sand dunes, to the existence of this "coffee-rock." We must recognize that this additional process of podsolization is a contributory factor in the origin of certain types of dune lake.

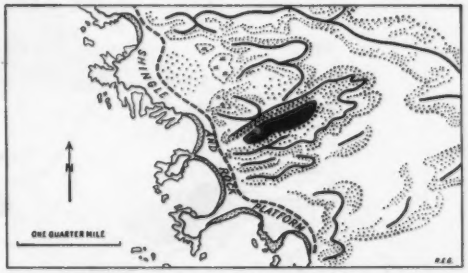


Fig. 8. Lakelet half a mile south of Currie (α *on Fig. 1*)

[1] In the past efforts were made to drain this hollow through the very low ridge of sand separating its western end from the shore, but recently this breach has been sealed to make the lakelet permanent as part of the water supply of the township.

In the calcareous dunes, the development of aeolianite does not apparently render them sufficiently impermeable generally to favour lake formation, though there may be some accumulation of impermeable residuals in the hollows to account for their rather greater frequency in the calcareous Old Dunes. One group of lakes within the calcareous New Dunes perhaps provides an exception which may be taken as proving the rule. West and north of Lake Flannigan (Fig. 5) there are four small lagoons, of which at least two are markedly intermittent, occupying parabolic dune hollows within the outermost wave of New Dunes. These hollows lie very nearly at the level of Lake Flannigan and it would seem that the large water body of this dune barrage lake on its impervious floor maintains the watertable at a high level within the neighbouring part of the New Dunes and so accounts for the dune-enclosed lakes nearby.

The New Dunes are commonly highest and thickest along their inner margin and thus there is often a belt of high watertable along their contact with the Old Dunes. Hence a line of lakes and swamps along the foot of the steep inner wall of the New

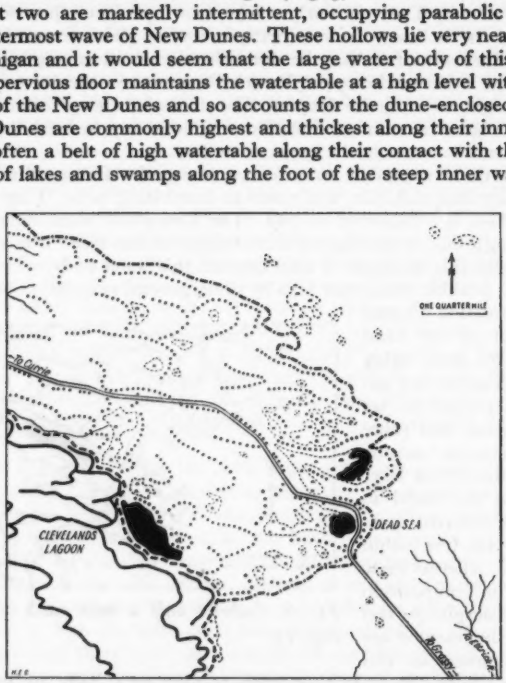


Fig. 9. Dead Sea and Cleveland's Lagoon

Dunes and set amongst the Old Dunes with their impervious subsurface seal is a recurrent feature of the island's geography. Cleveland's Lagoon (Fig. 9) is typical. In consequence also one can find examples which partake of the characters of both dune barrage and parabolic dune hollow lakes. This composite type is well illustrated in the north-east of the island (Fig. 10) by Lake Martha Lavinia and Penny's Lagoon, both of which lie about 20 feet above sea level. Penny's Lagoon, the simpler of the two, fills practically completely the central depression of an elongated parabolic dune. Its long dimension parallels the direction of advance of the dune and of the dominant wind for this coast from the east. A low sand ridge encompasses it on three sides and the parabolic curve of the western end fits the pattern of this ridge. The eastern shore of the lake truncates this parabola and is constituted by the steep rise of the high New Dunes to the east. But waves coming along the full length of the lake under westerly storm winds have eroded these dunes to fashion a beach of flat arcuate plan. Lake Martha Lavinia also has its major W–E reach in an axial depression of an elongated parabolic dune of the old system, though it fails to reach the apex of the parabola. On the north-east the lake lies under the high wall of the New Dune system: the slightly sinuous shore accords with short parabolic dunes, bulging from

the major foredune which separates the lake from the shore. The peninsula which projects into the lake from the north-west is part of a second and inner foredune of the new system, and the short northern arm of the lake runs along the swale between the two foredunes. At the eastern end of Lake Martha Lavinia, the white beach and sandcliff cut in the leached Old Dunes contrasts vividly with yellow sand exposed along the New Dunes of the northern side.

King Island is a comparatively small island and certainly it is an island of simple relief; yet the examples described show that within this compass there is a wide range of lakes associated with dune building. Their variety of form and genesis reflects not only the interaction of dunes with the topography into which they advance, but also the interplay of dune systems of quite distinct ages and the effects of other factors, including wave-built features, pedological processes, and changes in the relative level of land and sea. This discussion emphatically supports a comment, which the great limnologist, Forel, made over half a century ago: "Die seebildenden

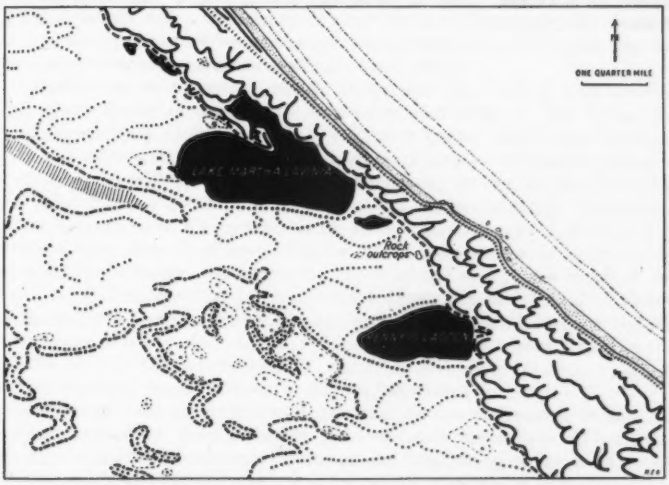


Fig. 10. Lake Martha Lavinia and Penny's Lagoon

Faktoren können sich in sehr mannigfacher Weise kombinieren. Das muss in jedem einzelnen Falle untersucht und festgestellt werden; die Zahl der Kombinationen ist zu gross, als wir hier alle aufzählen und klassifizieren könnten" (Forel, 1901, p. 21).

Acknowledgements.—Professor S. W. Carey, University of Tasmania, introduced me to King Island and my work on the island has been in continuation of earlier, incompleted work of his. I am also grateful to Professor O. H. K. Spate for reading and suggesting improvements to the manuscript of this paper. King Islanders, too numerous to mention individually, helped me most willingly in matters of information, accommodation and transport and I owe them many thanks.

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ASYMMETRICAL VALLEYS OF THE CHILTERN HILLS

C. D. OLLIER AND A. J. THOMASSON

THE INTERPRETATION OF slope is one of the fundamental problems of geomorphology, and the problem is nowhere more evident than in asymmetrical valleys, where closely related slopes have obviously had different developmental histories. In the course of a soil survey of part of the Chiltern Hills it was noticed that many valleys were asymmetrical, not only in relief but also in soil pattern, and the study of these valleys has thrown light on both the geomorphology and pedology of the region. The geomorphic results will be given here. Although this paper is mainly concerned with the Chiltern valleys and a hypothesis of their mode of formation, the discussion is extended to the general problems of slope development, and it is hoped that some of the conclusions reached may have applications elsewhere.

The literature on asymmetrical valleys shows that they have a wide distribution, and that many causes of asymmetry have been postulated. It also brings out the nature of the problem clearly; reveals how little is known about slope development, and indicates what sort of information is required before real understanding of the processes involved will be achieved. It is unnecessary to discuss the type of asymmetrical valley that is due to structurally controlled uniclinal shifting. However, many valleys are asymmetrical where there is no such control. In western Europe, where these valleys have often been described, the south- and west-facing slopes are usually steeper than those facing east or north. Many of the valleys are in chalk country (Geukens, 1947; Pinchemel, 1954), but examples have also been found on Pleistocene gravels in southern Germany (Büdel, 1944), and glacial outwash sands in the Netherlands (Edelman and Maarleveld, 1951). Similar valleys have been found in the arid west of the United States (von Engeln, 1942), in Wyoming (Walker, 1948), and in areas of permanently frozen subsoil in Siberia (Shostakovitch, 1927).

Explanations of these differences in degree of slope can be grouped under a number of headings. Insolation, wind direction and vegetation cover have all been cited by various writers as affecting the rate of erosion and weathering on opposite slopes, and until further evidence is forthcoming it is impossible to attribute asymmetrical valleys over such a wide range of climatic regions to any one factor. More important, however, is the lack of agreement as to the effect of different rates of erosion. Does intense erosion cause a slope to steepen or decline? Until this question is answered either slope may have been eroded more rapidly. Is an asymmetrical valley always asymmetrical or is asymmetry developed after down-cutting has ceased? Solifluction phenomena associated with former cold conditions are frequently mentioned as a cause of asymmetry, but here again there is little agreement as to whether a snow cover erodes or protects. Finally, would increased erosion on a valley side alter the shape of the slope, or may it not retreat parallel to itself?

Clearly many factors are involved in the shaping of a slope, but the processes that have formed it must leave their mark on its shape, and in the nature of the deposits on the slope. The two features, slope form and slope deposits, provide the best clues for identifying the slope-forming processes. Several studies have been made of slope form, for example, by Strahler (1950) and Savigear (1955), but slope deposits have not been studied in the same detail. These deposits normally represent a balance between weathering in situ and a gain or loss of material by soil-creep or rainwash down the slope. Soil creep is a common phenomenon on sloping terrain in temperate latitudes, but there is strong evidence that mass movement of soil material (solifluction) is considerably greater under periglacial conditions, when there are seasonal or

diurnal variations between hard frost and complete saturation with meltwater. Such conditions probably affected most of north-west Europe during parts of the Pleistocene period, and many slope deposits may therefore be unrelated to the present-day climate. In areas where valleys cut through different geological beds, the origin of the slope deposits can often be determined by their colour, stone content and mechanical composition of the finer fractions. These characteristics, and also the nature of the junction between drift and bedrock, provide important information on the relative rates of erosion on different parts of the slope, and the turbulence, or extent to which underlying material has been incorporated into the drift, during its movement downslope by soil creep or solifluction.

The area known as the Chilterns is a chalk plateau, dipping gently south-east, covered by deposits of later date, and dissected by valleys, mainly dry, which cut through the upper deposits into the chalk. It is a suitable region for this type of study because it lacks complications found in many other areas. It has structural simplicity and homogeneous lithology, and these advantages outweigh the disadvantages that the valleys being dry are therefore atypical, and that the forms may be complicated by solution of the chalk. It is generally agreed that the valleys were formed by running water, but whether the water ran over the surface of the chalk, because the ground was frozen, or because the water-table was higher, is still a matter of controversy. It is not really part of the present problem and will not be discussed further, but it is worth stressing that by becoming dry the valleys have been left in a stage of youth, relics of an early period of erosion, and their features are "fossil" and not related to present-day conditions. Valleys of the English chalk country have been described as having "unusually smooth slopes" (Bull, 1942), but asymmetry has been noted by Wooldridge and Morgan (1937) and particularly by Kennard (1942). The asymmetry is not obvious, for all slopes are comparatively gentle, but the asymmetry can be seen on the ground (see photographs facing) or on contour maps.

Relief.—The asymmetry of relief is brought out in Figure 1, which is a generalized slope map of part of the Chilterns. The construction of the slope map is described in the appendix. This area near Chesham (O.S. 1/25,000 map SP/90) is selected because it contains both large and small valleys which run in a number of directions, but it is typical of many parts of the Chilterns. It is clear from the map that in many cases the opposite slopes of a valley are not equally steep, and that in most cases where a valley is asymmetrical it is the west-facing slopes and, to a lesser extent, the south-facing slopes that are steeper. The south-west to north-east valleys are strike valleys, and it may be that the asymmetry is here due to structurally controlled uniclinal shifting.

In cross-sections of these valleys it was found that opposite slopes have different forms of combinations of slope units as well as different average gradients. A particularly good example of this is the dry valley of Little Hampden, 3 miles north-west of Great Missenden. It runs from north to south, without the complications caused by large tributaries or changes of direction. Figure 2 is a cross-section constructed partly from contours on the Ordnance Survey map and partly from clinometer readings and slope sketches made in the field. In studying a slope it is convenient to divide it into slope units and several methods are available. There is little basic difference between the terminologies suggested by various authors, and that of Wood (1942) is used here. The small convex portion at the top of the steep slope in Figure 2 is the waxing slope, the chalk outcrop is the free face, the straight but debris-covered slope below is the constant slope, which merges into the concave waning slope. This combination of units is believed by many authors to result from the retreat of a slope parallel to itself. The free face is an exposure of bare rock, and its retreat maintains a sharp angle at the top; that is, the waxing slope is kept short. The constant slope and waning slopes are covered with debris derived from the waxing slope and the free face. The opposite gently sloping valley side has only a waxing and a waning slope, which could be explained in many ways. Slope analysis alone does not enable any

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1. Hawridge vale, looking south-east, near Chesham; steeper, wooded slope on left

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2. View towards north-west over Chesham church

3. Valley near Pednor farm, looking north

definite statement to be made about the mode of origin of such a valley side, but is useful when studied in conjunction with the evidence of the drift deposits.

Deposits.—The Soil Survey of England and Wales has carried out mapping on the Aylesbury sheet (O.S. 3rd edition Sheet 238) and the pattern of soils and deposits over the chalk country of this sheet is known in some detail. Figure 3 is a soil map of Little Hampden valley across which the section (Fig. 2) was constructed, and

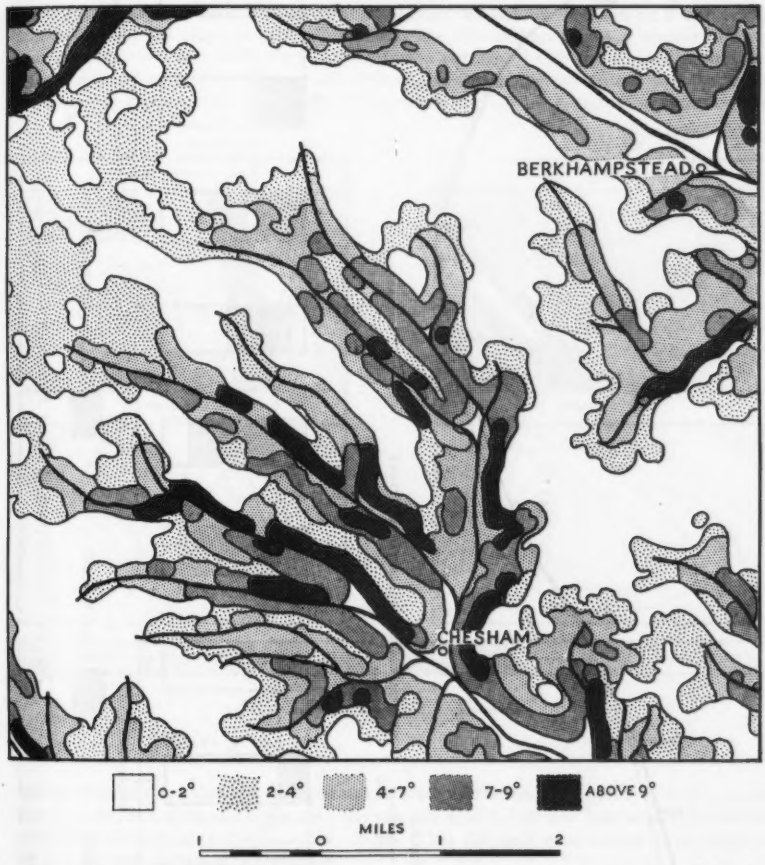

Fig. 1. Generalized slope map of an area near Chesham (O.S. 1/25,000, SP/90)

Figure 4, an area near Chesham, shows the pattern as found on an asymmetrical spur between two asymmetrical valleys. Detailed descriptions of the soil series mentioned are given in Soil Survey Reports Nos. 4 and 5, H.M.S.O. 1952 and 1953, and only short descriptions will be given here. Flat-bottomed "through" valleys such as Wendover gap have been affected by lateral corrosion and do not always show any marked asymmetry of slopes. The soil pattern in these valleys is, however, very similar to Figure 3.

The deposits along a cross-section in Little Hampden valley (Fig. 2) were studied

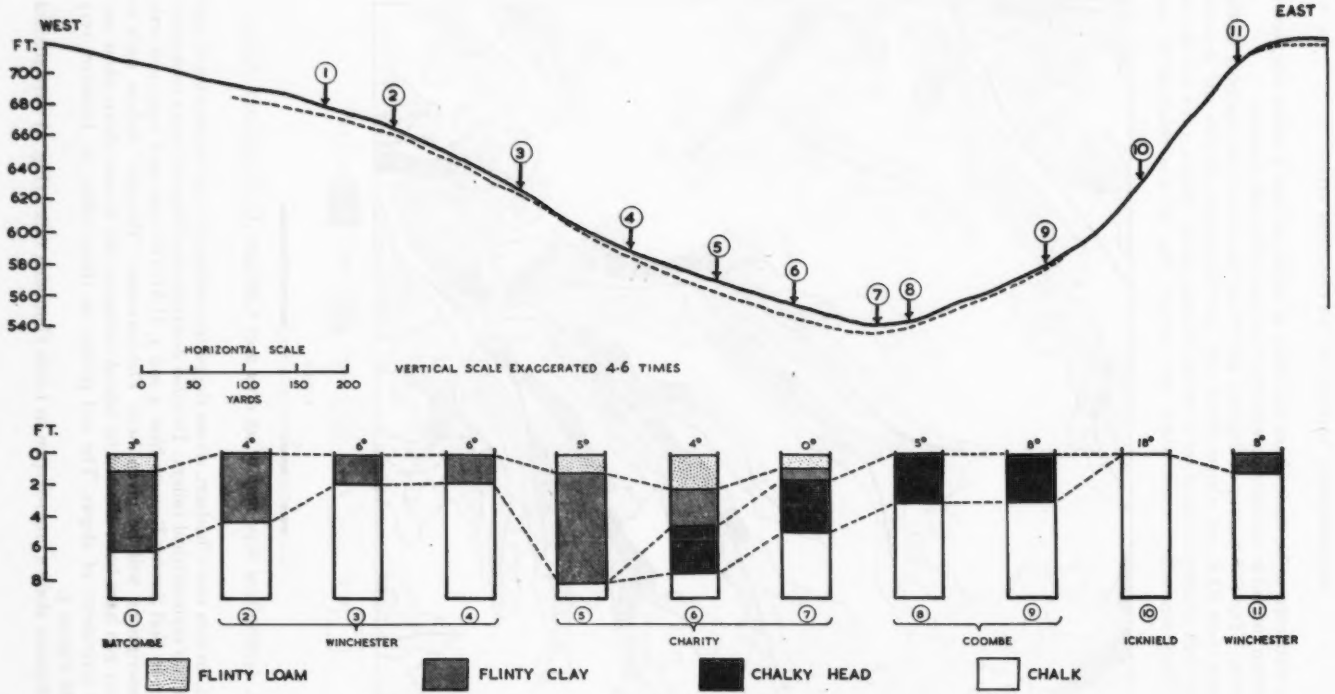

Fig. 2. Cross-section of Little Hampden valley

at eleven pits and auger borings. The chalk surface is shown by a dotted line, and its depth below the surface is drawn to the same scale as the slope section. Deposits and soils above the chalk surface are shown in the enlarged sections numbered 1–11. On the plateau surface is a deposit of flinty clay over six feet in depth. The term "Clay-with-flints" is avoided because many authors have used it with precise though differing meanings. At pit 1, which is somewhat below the plateau level, this deposit contains a great many flints, both unworn and shattered, in a matrix of clay or sandy-clay. The surface soil is a flinty loam and the profile is called the Batcombe series on the soil map. Further down the slope in pits 2, 3 and 4 is the Winchester series, a similarly flinty, but much heavier soil, with chalk nearer to the surface. In all these pits the junction between chalk and flinty clay is well defined. It should be noted that the Batcombe series is not represented at the top of the opposite slope although it is some 20 feet

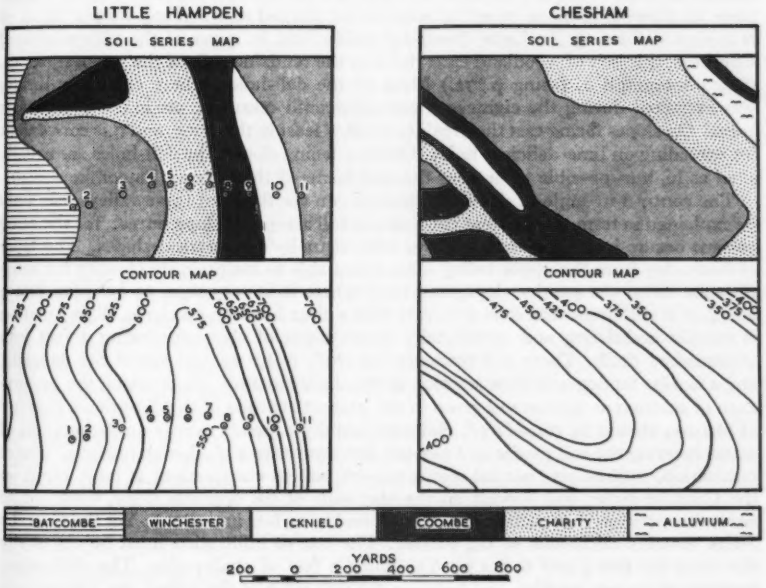

Figure 3

Figure 4

higher than pit 1. Also the Winchester is well represented to 590 feet O.D. on the gentler side, but does not appear on the steeper side below 680 feet where a rendzina soil (Icknield series) is developed on chalk. This Icknield zone slopes at an angle of 18 degrees and is virtually drift-free.

In pits 5, 6 and 7, the Charity series consists of a flinty loam of variable depth overlying a non-calcareous colluvium of flinty clay. In pits 6 and 7 a deeper horizon of mixed chalky and flinty clay occurs. The upper horizon contains a high percentage of loess-like material of a particle size 0·002–0·05 mm., classified as silt on the American texture scale. The underlying clay has a smaller but still significant proportion of silt, in which it differs from the clay of the Winchester zone. (Further details are mentioned in Soil Survey Report No. 8, H.M.S.O. 1955.) The Charity series is a naturally acid soil, and contrasts strongly with pits 8 and 9 (Coombe series) which are calcareous throughout. Here, the surface soil is still a flinty loam, probably also influenced by wind deposition, but the chalk content increases rapidly with depth and the profile has

the appearance of a head deposit derived from an intimate mixture of debris from the free face and waxing slope, which reached its present position by a process of turbulent soil creep or solifluction. The junction between head and solid chalk may possibly be lower than is shown in Figure 2. If this is so, the bedrock of the valley side would have an even steeper slope.

This pattern of soils has obvious effects on land use. The dominantly chalky soils on west-facing slopes have often suffered considerable erosion. The results of this can be seen in the bare chalk exposed on the downhill sides of field boundaries, and deep accumulations of top-soil on the uphill side. This is mainly caused by continuous ploughing on steep slopes. Another result of the soil pattern, noticeable on the 1/25,000 maps of the Chilterns, is that the heaviest soils (Winchester series), similar to pits 2, 3, 4 and 11 in Figure 2, are often occupied by woodlands. These soils contain numerous large flints, are difficult to work, and evidently some selection has taken place in allowing them to revert to scrub or be planted as woodland during times of recession in farming. In Little Hampden valley, and in many of the valleys around Chesham, this belt of woodland extends on to the rendzina soils of the steepest slopes. (See photograph 1, facing p. 72.) Most of the dell-holes, where chalk for liming was extracted during the eighteenth and nineteenth centuries, are in the Winchester zones. On slopes facing east the depth to chalk is least in this zone, and it is convenient for spreading on lime-deficient fields. On west-facing slopes, the dell-holes are usually sited as high as possible to be near the acid loams of the plateau (Batcombe series).

The contrast in angle of slope and deposits, on the flanks of these valleys, can only be explained in terms of different processes of soil creep and slope retreat, for the same pattern occurs in neighbouring valleys with virtually symmetrical slopes. The layer of flinty clay from the upper valley sides seems able to maintain its identity for some distance down the gentler slope, and even where it is very thin, as between pits 3 and 4, it is still non-calcareous and rests with a clear junction on chalk. This junction is usually undulating and occasionally shows pipes of clay penetrating 2 feet into undisturbed chalk. There is a tendency for chalk to be washed out of the deposits, and a similar tendency to slow solution at the chalk junction. In assessing the importance of solution as against soil creep in the present attitude of the deposits, a number of features should be considered. Solution activity depends mainly on the amount of water entering the soil profile and moving downwards to a chalk-rich horizon. Under cultivation, infiltration (rainfall minus run-off, minus evaporation) is most rapid on the Coombe series and slowest on the clay soils of the opposite slope, while under natural vegetation these differences would tend to be less important. Yet the Coombe series remains calcareous to the surface. The rate of infiltration must be essentially the same for pits 5 and 6, yet pit 6 contains 2 feet of chalky clay. The differences between these two profiles, and between the two sides of the valley, are ultimately a result of factors other than solution. We are led to assume that either the movement of soil material down the east-facing slope, almost to the valley bottom, was far more gentle than on the opposite slope, or that it is a considerably older slope and solution activity has proceeded for a longer period of time. An example of non-turbulent creep is described by Cotton (1952)—"Friction at the base is negligible, the creep is something like movement on ball-bearings." Furthermore, this creep must take place after the cutting of the chalk slope to its present shape. The two processes cannot be contemporaneous as a chalky clay mixture would be formed down the whole length of the slope. The presence of such a mixture at pits 6 and 7, in the bottom of the valley, must be related to a churning type of creep or solifluction which was in progress at a time when this part of the slope was still adjusting itself to an active stream in the valley-bottom. Once the main chalk slope on this east-facing side was established, and mantled with a slowly creeping layer of flinty clay, conditions became relatively stable. The absence of any deep accumulation of drift at pit 7 means that removal, presumably by a stream, had kept pace with the supply. Rainwash after this stage probably eroded the drift surface between pits 3 and 4.

Three main factors appear to have contributed to the pattern of slopes and deposits in Little Hampden valley. The slopes underwent two different processes of soil-creep, and a stream was active in the valley bottom. The possible interactions of these will be discussed in the next section.

We are now in a position to consider the possible mechanisms by which asymmetrical valleys are formed, and to discover which is the most likely in the Chilterns. At this stage, it is best to keep an open mind about the final cause of asymmetry (insolation, wind direction, or other climatic phenomena), and to confine our attention to the manner in which such valleys can be formed. It is clear from Figure 2 that the asymmetry is due to erosion, not deposition, for the chalk surface itself is markedly asymmetrical. Thus, although there may be accumulations of drift which are relatively greater on one side than on the other, there is at the root of the problem some process of erosion operating differentially. This point is particularly important as asymmetry has sometimes been attributed to differential deposition of wind-blown or solifluction material. Although the processes of weathering and waste-removal were obviously different on each side of the valley, there are still many possibilities, depending on whether erosion causes a slope to decline (Davis, 1932), or to become steeper and retreat parallel to itself (Penck, 1924). Also it is important to know whether the stream is actively down-cutting or not.

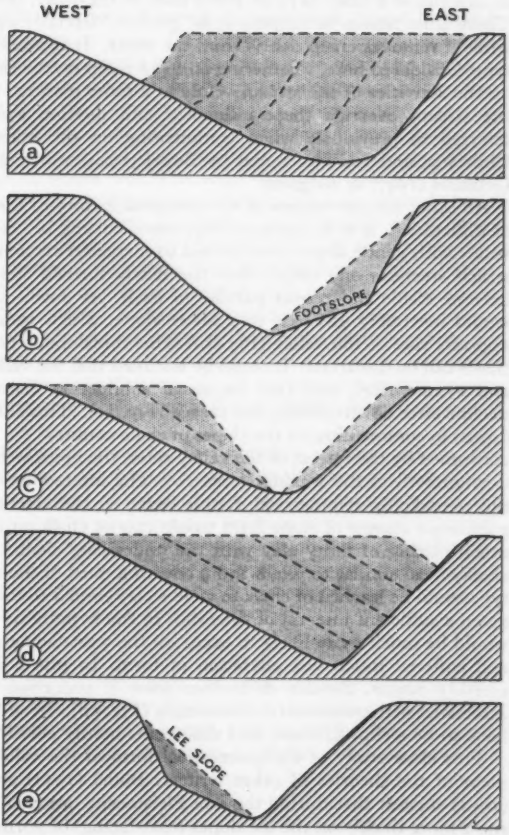

Fig. 5. Sketches illustrating the manner in which asymmetrical valleys may be formed

The most probable explanation is that asymmetry developed at the same time as down-cutting. The west-facing slope experienced considerable creep erosion under conditions which did not affect the east-facing one. The individual slope units attained their maximum slope under the prevailing conditions and the slope as a whole retreated (Fig. 5a). As down-cutting was going on at the same time no pediment was formed at its base, but only a graded waning slope, on which rested a thin layer of debris from upslope. The debris was thoroughly mixed and the deposits on this

side underwent turbulent creep. The opposite slope is to be regarded almost as a slip-off slope. The main stream shifted steadily east leaving behind a graded chalk slope, on which the layer of flinty clay moved gently downwards by non-turbulent creep. Only in the valley bottom, where conditions might be expected to be different, are the deposits to some extent mixed.

The theory is in some ways similar to those of Smith (1949) and Geukens (1947), but is different regarding the cause of the lateral shift of the stream. If creep erosion on one side of a valley is more active than on the other, the stream must move laterally. There is no reason to suppose it is "pushed" laterally by creep debris from one side while it removes creep debris from the other. It appears that in young valleys of the type considered here, weathering and soil creep on the slopes exert a strong influence on the activities of the stream. Only at a more mature stage can lateral corrosion by the stream override these influences and develop symmetrical slopes. This was referred to previously when commenting on the main "through" valleys of the Chilterns, and was also noted by Büdel (1944) working in southern Germany, and Geukens (1947) in Belgium.

All other interpretations of the erosional history of these valleys present a number of difficulties. If it is supposed that down-cutting has ceased and that a symmetrical valley with gentle slopes is subjected to increased erosion by solifluction and hillwash which steepens one slope, then the newly formed steeper slope would eventually become stable and retreat parallel to itself. As down-cutting has ceased, its retreat would inevitably give rise to a lower slope, which would be even gentler than the opposite side of the valley (Fig 5b). This footslope is not present and so this hypothesis can be discarded. It could be assumed that the valley was originally steep-sided and symmetrical, and that increased solifluction caused the east-facing slope to decline after down-cutting had ceased (Fig. 5c). This situation is envisaged by Wood (1942) in commenting on the slopes of chalk country: "· . . the constant slope was soon consumed by the retreat of the valley sides, the upgrowth of the waning slope and the downgrowth of the waxing slope. . . . The interaction of these factors gives rise to the remarkably symmetrical double curve so characteristic of chalk regions." Such a dynamic change of slope form would expose chalk on the waxing slope and involve much mixing of flinty clay with the underlying chalk. One would expect to find a chalky head similar to pits 8 and 9 covering most of the slope. A head deposit of this type could be leached of chalk to yield a clay similar to the Charity profiles in Figure 2, given a sufficient interval of time, but in the hypothesis outlined here such a deposit would be much more likely to occur on the west-facing slope which was not reduced and suffered much less alteration of form. In pits 8 and 9 leaching of chalk has scarcely begun. Similar difficulties arise if reduction of the east-facing slope is associated with continued down-cutting (Fig. 5d). In addition the steeper slope would have to be a slip-off slope, and this seems hardly possible.

This close study of the geometrical form of the valleys is essential to any assessment of the theories of other writers. Büdel (1944) and Edelman and Maarleveld (1951) suggest that during the late Pleistocene dominantly westerly winds deposited snow more thickly on the lee slopes (east-facing) of normal symmetrical valleys. This slope would retain its snow-cover for a longer period and would be reduced by solifluction processes. Meanwhile meltwater would tend to gather at the foot of this slope and steepen the opposite snow-free slope. There is no specific mention of down-cutting by the stream, but such a combination of processes must fall into the categories of either Figure 5c or Figure 5d, both of which are inapplicable to the Chiltern valleys. In addition these writers assume that the upper shoulder of the east-facing slope will be reduced and graded to the rest of the slope. This is not necessarily the case. Snow on the plateau will be the same on both sides of the valley; no extra thickness of snow is deposited above the shoulder as only the slope is in the lee of the wind. Extra erosion could only take place on the slope itself, and if its lower part were reduced, the upper part could only be steepened (Fig. 5e).

In the areas studied by the above writers, and also in France (Pinchemel, 1954), deposits of loess tend to be associated with east-facing slopes, and it is thought that this adds some support to the theory that wind direction is a controlling factor in the formation of asymmetrical valleys. On the evidence accumulated here, we can offer a second alternative: that if wind deposition of loess were similar on all slopes, the different rates of erosion would tend to sweep it off a west-facing slope much faster than off the opposite side. For this reason the orientation of loess-covered slopes cannot be used to prove any specific wind direction during the Pleistocene.

Until a great deal more work has been done on asymmetrical valleys in widely separated areas and on different rocks, it is very difficult to ascertain the ultimate cause of this phenomenon. As the more intensely eroded slopes face west and south, it seems likely that insolation has some influence on the rate of weathering. The afternoon sun is generally warmer than the morning sun, so this process should be most effective on slopes facing south-west. The valleys were probably formed during the fluctuating climate of the Pleistocene, and one possibility is that under periglacial conditions, west and south-facing slopes would undergo diurnal or seasonal freezing and thawing while the opposite slope remained permanently frozen, or thawed out for only a short time during the summer. Periodic freezing and thawing would favour strong physical weathering and solifluction. To check this theory would require a considerable amount of close meteorological data from present-day periglacial areas, but the work of Shostakovitch (1927) in Siberia seems to point to this as a promising line of enquiry for areas which are known to have experienced periglacial conditions. However, similar differences occur in the arid west of the United States, outside the influence of very cold temperatures and here the effect of insolation on vegetation cover may have influenced the rate of weathering. At the moment we cannot be sure that the valleys of western Europe are not a result of interglacial rather than glacial processes.

No unequivocal solution can be advanced for the formation of these valleys, but it is believed the theory suggested here affords a reasonable explanation of the evidence of slopes and deposits. The assessment of the data obtained is made difficult by the lack of fundamental information about the relationship between slopes and the deposits on them. If the interpretation is correct then increased erosion on a slope, by turbulent creep, causes the slope units to attain their steepest optimum gradients, and the slope as a whole then undergoes parallel retreat. In this our conclusions support Penckian rather than Davisian ideas of slope development.

Acknowledgements

The writers would like to acknowledge the help and encouragement given to them by the staff of the Soil Survey and Pedology Departments at Rothamsted Experimental Station during the preparation of this paper, particularly by Mr. B. Avery, who has made many valuable suggestions, and Miss S. Pettitt, who prepared the maps and diagrams.

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APPENDIX

Construction of the generalized slope map.—In studies of relief a map showing the main slope features of an area is often useful. The slopes can be seen on a contour map, but general relationships are not at once apparent, and a more generalized slope map is desirable. Several methods of preparing maps of average slopes have been published. These are summarized by Monkhouse and Wilkinson,[1] but none of them were found suitable for the present work, and a new method was devised.

A circular hole in a piece of celluloid is used to delimit areas. This stencil is used in much the same manner as dividers set at a constant distance apart, but it is quicker and less subjective. The diameter of the circle for this work on the 1/25,000 map was 0·45 inch corresponding to 220 yards. The stencil is always placed on only one slope, and is not laid across a valley-bottom with both slopes included. To speed up the work a line was drawn along the valley bottoms. This would be unnecessary in an area of normal wet valleys.

The steepest areas are picked out first, such as a valley-side where the stencil can include 8 contours. The stencil is placed in this position, and a circle traced. The stencil is then moved around all the adjacent area where 8 contours can be included in the circle, and its positions marked by arcs. In this way a line is drawn around the area with sufficient steepness to have 8 contours in a circle of the particular size used. After marking out the steepest part, the area with slightly less slope, say 7 contours to the circle, is marked off in a similar way, and then the areas of 6, 5, 4 contours, and so on.

A disadvantage of this method is that a series of fringes of lower contour number always surround areas of high contour number, giving an erroneous impression of roundness. If, however, the areas of 0 and 1 contour are, as far as possible, marked off together before dealing with intermediate slopes the junction between plateau and valley-sides appears sharper. In the area treated here, this gives a much truer picture of the relief.

The advantages of the method are that it is rapid and easy to construct, the boundaries found correspond well with natural ones, it is sensitive to comparatively slight changes in slope, and shows the relationship of slopes clearly. The intensity of analysis can be altered by varying the size of the circle used, and more complicated variations of the method could obviously be devised to meet any special needs. The final slope units can be described in qualitative terms such as: rolling, gentle, steep, etc. or, if a more intense analysis has been attempted, they can be expressed in degrees after a simple calculation.

[1] Monkhouse, F. J. and H. R. Wilkinson, 1952. 'Maps and diagrams.' London, pp. 73–87.

FROM THE *JOURNAL* A HUNDRED YEARS AGO

THE FOLLOWING abstract is taken from "Notes" by Colonel Sir Henry Rawlinson, K.C.B., "On the ancient geography of Mohamrah and the vicinity." These notes were read on 11 May 1857, and may be found in the *Journal of the Royal Geographical Society*, Vol. 27, pp. 185–190.

"THE ground upon which Mohamrah stands has been formed by alluvial deposit within the historic period, and it is in vain, therefore, to search for the site in very remote antiquity. When Chaldæa was first colonized, or, at any rate, when the seat of empire was first established there, the emporium of trade seems to have been at Ur of the Chaldees, which is now 150 miles from the sea. The ships of Ur, at any rate, are constantly mentioned in the earliest inscriptions in connexion with those of Æthiopia, and there is abundant evidence among the remains of the city, of the worship of the sea-god, which alone would indicate a maritime people, and which, moreover, is in exact accordance with the early traditions preserved by Berosus. . . .

I must now say a few words on the island between the two arms of the Euphrates at the apex of which Mohamrah is built. This is usually called the island of 'Abadán, from a certain ancient city of that name which was built on it. *Hubadán* may perhaps be read, in connexion with Billah, in the account of the maritime expedition of Sennacherib. The island of Apphana at any rate is named by Ptolemy, and in Marcian we have the island of Appadan, lying off the mouth of the Tigris, which was 80 stadia, or about 10 miles from Spasini Charax, nearly agreeing with the 12 miles of Pliny between Forat and Charax. This island of course gradually increased in size as the deposit of alluvium continued, and is thus often mentioned by the later geographers as Mesene from its position between the two arms. . . .

It may not be thought, perhaps, of much importance that this hydrography should be traced in detail; still it would not be without its interest, if some of our officers during the present occupation of Mohamrah and encampment on the Karún, would endeavour to trace the old beds of the rivers, and identify the old names of the places along their courses. Arabic history and geography are full of notices on the subject, one or two of which I will add just to show the nature of the materials at our disposal. In a geographical work of the 3rd century of the Hejirah, and which is probably Ibn Khurdádbeh, the Postmaster's own compilation, we have a very interesting account of all the canals derived from the Euphrates. . . ."

THE AUSTRALIAN MAP OF ANTARCTICA

ANTARCTICA. Map produced by the National Mapping Office, Australian Department of the Interior, for the Antarctic Division, Australian Department of External Affairs. *Second edition (revised)* 1956. *Meridional scale* 1 : 10,000,000. 39 × 30 *inches*

THE FIRST EDITION of this Australian map of Antarctica was published by the Property and Survey Branch of the Department of the Interior in 1939. It was for many years the best general map of the continent. However, since 1939, much additional survey has been done and there have been many changes in place-names. Although the original map has continued in use for general purposes, its usefulness gradually declined. The publication of a second revised edition is therefore most welcome. Antarctica is at present the target of a more intensive international effort of exploration than at any previous period. It is therefore particularly opportune to attempt cartographic assessment of existing knowledge of the continent.

The general style of the new edition is similar to the original map, and the useful inset showing the relation of Antarctica to the neighbouring land masses has been retained. Much of the previously unexplored coast (a dotted line in the 1939 edition) has now been filled in; an advance which is especially noticeable in the larger scale inset, at 1 : 7,000,000, of the Australian Antarctic Territory. The map is clearly and well produced in six colours: lettering is in blue and black; mountains are lightly etched in brown. Ice fronts are shown, with the dates of their latest known position.

The representation of glaciers and ice streams needs more consideration; not only on this but on many other Antarctic maps and charts. The symbol used is heavily etched and has well-defined edges, suggesting that all the glaciers are similarly clear-cut and of the mountain (valley) type. This is misleading. The Beardmore Glacier, for example, is quite correctly represented as a valley glacier contained within rock margins, but a less distinct symbol is needed for ice streams, where one part of an ice sheet flows more rapidly than the surrounding ice. The glacier symbol used for what is presumably an ice stream on Roosevelt Island in the Ross Ice Shelf, for example, is most curious, and there are certainly no glaciers resembling those shown in Coats Land. This problem has been successfully solved on some of the new 1 : 500,000 sheets of Antarctica published by the United States Geological Survey, but the writer has not yet seen any glacier symbols which are really suitable for scales of less than about 1 : 1,000,000.

Antarctic place-names provide many difficult problems. With the exception of Svalbard, it is probable that in no part of the world have so many names been given, forgotten, mis-spelt and mis-applied. Many controversies over priority of discovery can be reflected in the use of competing place-names. The partisan use of place-names is the commonest and certainly the easiest method (open to every author) of expressing non-recognition of administrative authority. It is not therefore to be expected that maps produced in the United States (which recognizes no sovereignties in Antarctica) will use the same place-names as those produced in Australia, France, New Zealand, Norway or the United Kingdom—all of which recognize each other's sovereignty over sectors of the continent. Since the publication of the first edition of this map, the Australian, New Zealand and United Kingdom governments have all agreed to accept the principle that the ultimate decision on a place-name itself and the language in which it is written rests solely with the recognized administrative authority. This policy was first applied to the 1948 edition of the 'Antarctic Pilot,' published in the United Kingdom by the Hydrographic Department, and has since been followed in all other United Kingdom official publications concerned with Antarctica. The new Australian map is one of the first in which these principles have

been applied to the whole continent, and its publication therefore marks another important step towards the stabilization of Antarctic place-names. It not only provides an authoritative guide to the officially recognized place-names of the Australian Antarctic Territory, but is scrupulous in following the nomenclature and the language of the other administrative authorities within their sectors. Furthermore, cooperation between the Australian Committee on Antarctic Names, the United Kingdom Antarctic Place-names Committee and the United States Board on Geographic Names has already resulted in a very wide measure of agreement.

Apart from place-names, the production of such a map presents innumerable cartographical problems. There are notable differences of opinion on the best method of mapping this vast area of 5,500,000 square miles. Some hold that air reconnaissance and photography is the essential first step, to be followed later by more detailed work on the ground. Others maintain that air photography without detailed ground control is of relatively little value. It is unquestionably true that a great many more features have been "discovered" and named than can be plotted with any confidence on a map, and there are baffling differences in the reliability of the many different surveys which have to be brought together in a compilation of this kind. Those responsible for the new Australian map have wisely adopted a cautious attitude in sifting the masses of conflicting evidence. The reviewer has nothing but praise for the careful research which has gone into its production.

BRIAN ROBERTS

UNTRODDEN PEAKS

KANGCHENJUNGA THE UNTRODDEN PEAK. By CHARLES EVANS. *London: Hodder and Stoughton*, 1956. 9×6 *inches;* xx+186 *pages; map and illustrations.* 25*s*

ON CLIMBING. By CHARLES EVANS. *London: Museum Press*, 1956. 9×6 *inches;* 190 *pages; map, illustrations and drawings.* 30*s*

A PICTURE HISTORY OF MOUNTAINEERING. By RONALD W. CLARK. *London: Hulton Press*, 1956. 11×8½ *inches;* 200 *pages unnumbered; illustrations.* 30*s*

THE DAY HAS happily gone when it was thought necessary to find a "greatest" of mountaineering triumphs. Everest or Nanga Parbat or K2? We know that one climb increases the possibility of the next. And superlatives were pushed yet another degree out of place when, in the early June of 1955, the news came through that Charles Evans's "strong reconnaissance" of the complicated and almost unexplored southern flank of the world's third highest mountain had turned into a successful climb. I think that most mountaineers felt this to be the almost inevitable, if also the almost unbelievable, sequel to the other three ascents.

Charles Evans once remarked that he had found it difficult to write his book after reading 'The ascent of Rum Doodle,' Bowman's witty take-off of all Himalayan expedition books, with their inevitable chapters of preparation, march, build-up, assault, return and the rest. His own way of avoiding the Rum Doodle trap is to take the story at speed; to compress it into 147 pages and not to linger over introduction and finale; to use photographs and diagrams, both excellent, to make it absolutely clear; in short to carry the reader without detour to a point just short of Kangchenjunga's summit. For the summit itself, he had promised the Sikkimese authorities, was to remain untrodden.

Evans's narrative style, clear and terse and objective as the best in Eric Shipton, is the ideal instrument for his purpose. At times its simplicity is deceiving. "Either there was a way up it, or there was not. As it turned out, there was; and we followed

it." In this direct truthfulness the reader, climbing quickly as he must, may forget the long intricacy of that new way; the magnitude of the difficulty of placing a top camp past the two icefalls and up the Gangway at 26,900 feet; and of getting two pairs from it, even with the improved oxygen apparatus, up to the highest point.

Two luxuries the author has, I think consciously, foregone. First, that of giving a detailed picture of the mountain and country, except in so far as they affect the climb. Yet when I have said that, I recall the touches of descriptive colour and personal humour which salt the telling, as well as the sense of approaching climax in beauty, as in action. Moreover aesthetic feeling is deadened, high up, and here he is true to the experience of all who have been on big mountains. The second is a "round" picture of his companions, of whom, apart from titbits, little that is personal has time to appear. We see that they were men of high skill and loyalty; but those who know them would have enjoyed the individual, as well as the collective characterisation.

The summit was "a cone of snow, about twenty feet away." Kangchenjunga remains the untrodden, and after this story the unforgettable peak.

'On climbing' is a very different book, though the hand is clearly the same. It looks as if Charles Evans had been given a difficult task, or rather two tasks. He has set out to write a climbing manual, and he has also felt that a certain approach to the whole of mountaineering needed putting into words, with illustration, because there was a danger of the "mass-produced" mountaineer losing the initial, individual values. There can be nobody better qualified for these tasks, or who can speak with greater authority. At the same time, those most interested in Charles Evans's statement of values and his stories are likely to be those already fairly proficient in technique; while those who need a mountaineering manual may not be able to afford 30*s*. But I cannot lay this fault at the author's door.

It must be added at once that the way in which the given themes are interwoven is masterly. Anecdote illustrates the technical chapters, which are an education even to those who fancied themselves expert. Particularly authoritative are the observations on Himalayan, as compared with Alpine conditions. The book closes with four chapters of personal adventure, simply and most attractively recounted, in Wales, in the Alps and in the Himalaya. In these a whole attitude, as well as a very human way of thinking, is implicitly revealed. It is not, Charles Evans seems to say, the person drawn to the hills by badges or other rewards, still less the rock-only expert, who can be called the "happy climber." It is the boy who takes bicycle and rucksack to go off camping on the Berwyns; and who goes on from there. Everybody may not be able to lead a "Very Severe" rock climb. But everybody who has that boy in his heart can become the complete mountaineer.

'A picture history of mountaineering' is an attractive book to browse in. Ronald Clark first compresses his subject into some ten pages (a formidable task) and then reels off 350 illustrative plates, with lengthy captions.

I personally found the pictures fascinating, particularly some of the early ones which must have been very difficult to come by. They are well reproduced. The history and captions I found irritating; not more so, doubtless, than Mr. Clark found them to compress. It is hard to avoid the impression that the story was affected by the photographs available. Thus a whole three pages are devoted to the not really important 1930 Kangchenjunga expedition (a few words to the successful one, but that may be due to copyright) and one to the Scottish Garhwal expedition. Yet Kellas in the Himalaya is not mentioned; nor Herford or Brown at home; nor, except in very general terms, the brilliant new climbs done in the Alps by Brown, Whillans and other members of the A.C.G. A short history is bound to omit something, and everybody's spotlight to be different. But in that case it would perhaps be better to call it "Pictures from mountaineering history," and leave it at that. Some mistakes spring to the eye. Petrarch's ascent was in 1336, Ramthang and not Wedge Peak was climbed in 1930, Makalu is the world's fifth summit and the Eigerwand was

first climbed in 1938. But these and others will doubtless come out in Mr. Clark's longer history, to which this must be regarded as an agreeable hors d'œuvre.

WILFRID NOYCE

NAVIGATION FROM ODYSSEUS TO COOK

THE HAVEN-FINDING ART: a history of navigation from Odysseus to Captain Cook. By E. G. R. TAYLOR, with a foreword by the Hydrographer of the Navy. *London: Hollis and Carter*, 1956. $8\frac{3}{4} \times 5\frac{1}{2}$ *inches;* xii+295 *pages; plates and figures.* 30*s*

LOOKING AT THE ranks of the many volumes devoted to sea travel, it is difficult to realize how recently has been taken up the serious study of the history of the art of navigation. Indeed, many people would give Professor Taylor the credit of inventing this course of study, if she did not carry her learning so lightly. Certainly we all owe much to the Institute of Navigation and to its Executive Secretary for the encouragement given to Professor Taylor both to devote herself to her chosen study and to publish her conclusions expressed so lucidly. 'The haven-finding art' is a model of packed information, narrated clearly and amusingly, with just the right amount of illustration and reference to the original sources. This is a book with a wider appeal than had her 'Mathematical practitioners' but it is no less important.

The story closes with the successful invention of the marine timekeeper and the brilliant navigations of Captain Cook, and Professor Taylor has spaced out her material into five parts. The two chapters in part one, on the signs in the sky and the surface and floor of the sea, give the background of geographical knowledge and how it would affect the earliest navigators. Now all this is equally true today though not so obvious in the big ships fitted with every modern navigational convenience. Any yachtsman will be vastly intrigued to read and discover what the wind he keeps trained on his starboard ear or the star held dancing over the cross-trees might have meant to the ancient mariner sailing away from the land before the invention of chart or compass. His problem, the problem of the Phoenicians and Greeks, Irish and Norsemen, is discussed in part two. The Irish monks managed to cruise in such incredibly unseaworthy boats, stone troughs and the like, that one is not surprised that they could also navigate. With the Norsemen it is different; for we know their ships almost as well as we know our own, double-ended, clinker-built, pulling and sailing boats of some 70 feet in length, obviously capable of making ocean passages and reaching Iceland, Greenland and America. But how did the Norseman navigate? Kindly moderns have designed for him handy little gadgets for reading off angles, and have tried to allow him the mariner's compass; but the one straightforward account of a Norseman's voyage of exploration, told by Octhere to King Alfred names none of these things. And hints found in the garrulous saga literature only suggest clues which cannot be followed up. No doubt the changing appearance of the sea and sky, the steadiness of a prevailing wind, the regular movements of the heavenly bodies, all assisted the trained voyager, but it is also true that the Norseman usually discovered new lands when he had lost his way looking for the old ones.

The suggestions as to the possible use of birds fascinate because it is only recently that the bird's own navigational equipment has been scientifically investigated. Some valuable information on the routes taken by migrating geese is given on the authority of Commander Peter Scott. An unnamed modern authority is quoted as claiming to note where the land lies from "the majestic flight of the homing gannets;" the gannet, who often lives on an isolated and inhospitable rock, and therefore possibly has no good reason to go home at nights, has always seemed to the reviewer a singularly

unsatisfactory sky pilot. But the geese, migrating between Ireland and Iceland in the spring and autumn, different flocks following each other over a period of weeks, seem possible and proper pathfinders. Unfortunately the sagas have little to say about birds and Floki's three ravens were used by him in the manner of Noah's dove.

Part three, which deals with the introduction of compass and chart amongst Mediterranean seamen, covers a story which Professor Taylor has told before but never better. Despite the obvious values of the early pilot books, charts, compass, sand glass and lead line, the really useful knowledge must still have lain in the head of the experienced pilot. Chaucer, with the true poet's vision of practical matters, etches for us in memorable lines the well-stored memory of his Shipman, who added an understanding of the tides to the traditional lore of the Mediterranean sailor.

In part four we meet Prince Henry the Navigator and study the new instruments and books of tables carried on the great voyages of discovery which Prince Henry so nobly fathered.

Of the eleven chapters which take us from Odysseus to Cook, it is chapter nine which bears the title "The English awakening;" and they are still awake. The early Tudors were cruel, clever men with hard hearts who summoned foreign shipwrights and pilots to this country with the result that by the reign of Elizabeth I skill in shipwrightry and navigation had become the Englishman's birthright. With well designed, accurately divided instruments went the possibility of better navigation, whether by dead reckoning or celestial observation. By the seventeenth century ships could be called seaworthy; indeed one small English ship, Drake's *Golden Hind*, but 75 feet long, had encompassed the world and got into no serious trouble on the open seas. But the dangers of shipwreck were always present to the sailing ship and could only be avoided by the careful forethought on the part of the navigator, who therefore demanded very much better charts.

In part five Professor Taylor crosses into the eighteenth century, and with no lack of confidence describes admirably the progress towards mathematical navigation and the solution of the all important problem of longitude by the invention of a reliable marine timekeeper. The triumph of the invention of the chronometer rounds off her story. Once again in this country the practitioners go hand in hand with the observers, in this case John Harrison with James Cook. Against strong foreign opposition, Spanish, Dutch and French, Englishmen manage to hold their own as astronomers, instrument makers, shipwrights and navigators. Professor Taylor has told her story freshly and lucidly; indeed magnificently. Geographers, whether they be seamen or students, will find her book both a delight and a necessity; for she has written a story which both tickles the fancy and feeds the understanding. G. P. B. NAISH

REVIEWS

EUROPE

SHEFFIELD AND ITS REGION: a scientific and historical survey. Edited by DAVID L. LINTON. *Sheffield: British Association for the Advancement of Science*, 1956. 10×7 *inches;* 334 *pages; maps and illustrations*

For the 1956 meeting of the British Association, Professor Linton and his contributors have prepared a regional survey which, to say the least, is fully up to the extremely high standard set by the post-war volumes of this series, both in content and presentation. Regional surveys written by a number of hands can be extremely dull: no contributor considers he is given enough space to do justice to his subject, so that only what is basic, and commonly known, goes in, while the "growing points" of knowledge, being highly specialized, are crowded out, although it is just at these points of growth that a subject is most alive and interesting. It is the virtue of this survey that the contributors really revalue, and not merely repeat, the older material, and manage at least to indicate the directions in which research is proceeding. Not least is this shown in the editor's introduction and in his own contribution on the geomorphology of the Sheffield region, a revelation even to those who thought they knew the region well.

The boundaries set to the Sheffield region in this survey are rather larger than those of the classic "Peakdon," and include Buxton in the west, Matlock and the Chesterfield–Clay Cross region to the south, and much of Sherwood and the Keuper country to the south-east, reaching as far as the Trent. This rather surprisingly wide frame, however, is retained mainly for the more basic studies, such as physical geography, the section on prehistory, with its fascinating series of maps, and for Mr. I. S. Maxwell's fundamental contribution on Anglo-Saxon and Scandinavian settlement. With the introduction of current human geography, attention narrows upon Sheffield itself, which is treated in great detail, and the region rather drops into the background. Although doubtless inevitable, this is a pity, for the region is a distinctive one. When reading Mr. Hunt's interesting account of the morphology and development of Sheffield, for example, one regrets that there is no comparable study of the coalfield, with its distinctive landscape of old sandstone villages on the ridges, red brick miners' rows dropping to disused canals, little hedged fields and woods, and the great houses of coal-owning Whig lords, with opencast workings tearing up their parks. This, however, is a small criticism of a most useful work, which will be invaluable for future students of the region, and which gives such convincing evidence of the vitality of the scientific investigation of Sheffield and its district today. T. H. ELKINS

GÉOGRAPHIE UNIVERSELLE DER TRANSPORTS. BY H. LARTILLEUX. Tome 1. GÉOGRAPHIE DES CHEMINS DE FER FRANÇAISES: Volume 1. S.N.C.F. *Paris: Chaix*, 1956. 11×8 *inches;* 369 *pages; maps and plates*

Whilst many books are published on railways, no other is of such a monumental character as this great 'Géographie universelle des transports.' The volumes which have already appeared are:

Tome 1: Volume 1—Railways of France (S.N.C.F.); Volume 2—Minor railways of France; Volume 3—North African Railways; Volume 4—Railways of Distant French Territories.

Tome 2: Volume 1—Swiss and Italian Railways; Volume 2—Railways of the Low Countries, Luxembourg and Iberia.

This volume on the S.N.C.F. lines has a short introduction on the history of the French railways and an appendix which covers in short sections the secondary lines,

the Métro of Paris, the rack lines and funicular railways, and seven chapters which give regional accounts of the routes.

To give an impression of the scope of the volume, a survey of, for example, Chapter 4, "L'ouest" is useful. There is a brief historical review of the growth and then consideration in turn of the radial routes of Normandy, Brittany and Vendée–Océan with a concluding section on the transverse routes. Under Normandy, as with each of the other divisions for the whole of France, is an account of the principal terminus in Paris, showing not only its development, but also the routes leading to it, with emphasis on junctions and numbers of tracks. Thereafter follows a description of each radial route with reference to gradients and junctions. The whole is a concise and admirable summary, and, as such, is indispensable to anyone wishing to study not merely the railways of France, but also the impact of the rail transport on any region.

Perhaps it might be thought that such an encyclopaedic account would be dull. It is far from being so. There are nine excellent regional maps in colour and 280 maps in the text which illuminate local details in relation to relief and settlements. In addition there are many photographs which illuminate the relationships of railways to the landscape. For all who have to consider France, this authoritative account of the S.N.C.F. lines by their chief engineer, will remain an essential reference work. It is to be hoped that the remaining volumes will be published without undue delay.

A. C. O'DELL

FRANKEN. Edited by CONRAD SCHERZER. *Nürnberg: Verlag Nürnberger Presse Drexel, Merkel*, 1955. 9½×6½ *inches; 498 pages; plates, maps*

Franconia is German countryside at its most romantic, with dark, wooded scarps overlooking half-timbered villages set among strip fields, with the Main swinging beneath vineyards crowned by castles, and with towns that have scarcely outgrown their medieval walls. The region has attracted more than its share of the subjective literature of the *Heimatkunde* school, but the present work, while no less inspired by these superb landscapes, really makes an attempt at a scientific regional study, a more elaborate version of the type of survey which, in our own country, generally depends on the accident of a visit by the British Association for its completion. After a brief physical introduction, in which the emphasis lies on geology and lithology rather than on the evolution of surface and drainage, the first half of the book is devoted to an extremely detailed description of the "natural" regions of Franconia, including not only physical but human geography. This is in some ways unfortunate, as subjects like land use and settlement geography are thus introduced in advance of the illuminating general sections on biogeography, prehistory and the period of settlement up to about A.D. 1000. The coincidence of physical and human distributions is thus somewhat prematurely, although not necessarily incorrectly, suggested, and a picture of Franconia as a whole, as distinct from its parts, does not entirely emerge. For this, presumably, we must await the promised second volume, dealing with later history and economic, social and cultural topics. Even as it stands, however, this lavishly illustrated book is essential reading for any geographer wishing to study or to visit this most attractive and diverse country of Franconia.

T. H. ELKINS

THE MAKING OF DUTCH TOWNS. By G. L. BURKE. *London: Cleaver-Hume*, 1956. 10×7 *inches; 176 pages; maps and illustrations. 55s*

Presented as a study in Dutch urban development up to the seventeenth century, it is at once apparent that much care has been applied in the preparation and presentation of this book. The growth of Dutch towns is outlined according to a classification of their layout; numerous examples are cited and are supported by photographs and diagrams of exceptionally high quality and by reproductions of old town plans by van Deventer and other masters. The intention is to study urban development in the Netherlands as a whole, and there is no attempt to adopt the encyclopaedic approach

which recounts the progress of each town or city. For this reason there is, for example, only brief reference to Dordrecht, Rotterdam and Harderwijk, and none whatever to Schiedam or den Briel. There are, however, rewarding studies of less well known, smaller towns of whose history and development little has hitherto been written in English.

In order to overcome the disadvantages of their environment the Dutch have been forced from the earliest times, in matters vital to community interest, to accept some form of overriding discipline which did not offend an advanced sense of the importance of personal liberty. A high proportion of towns in the Netherlands were consciously planned, and although achievements in this field were not spectacular they were substantial. The impression is conveyed that a nice balance was achieved between the exigencies of the time and the legitimate interests of the ordinary citizen.

The book is well balanced by several chapters which recount the economic and historic background of the period and the procedure by which practical town planning functioned. There is one chapter devoted to Amsterdam, and there is also included a bibliography (which strangely omits to mention the work of Geyl in the history section), and a short glossary of Dutch terms. The sketch-maps which portray topographic changes since Roman times and the site positions of the towns mentioned, are not of the same high standard as the remainder of the book, which is otherwise both accurate and admirably illustrated and printed. H. THURSTON

RICERCHE SULLE DIMORE RURALI IN ITALIA, Vol. 14, LA CASA RURALE NELL'UMBRIA. By F. BONASERA, H. DESPLANQUES, M. FONDI and A. POETA. Vol 15, LA CASA RURALE NELLA PIANURA E NELLA COLLINA LOMBARDA. By F. SAIBENE. *Florence: Leo S. Olschki, Consiglio nazionale delle ricerche*, 1955. 12×7 *inches;* xii+220 *and* xv+222 *pages; maps, plans and illustrations.* 2500 *lire and* 2400 *lire*

These volumes contain two more instalments of the rich documentation in text, photographs, sketches and maps on Italian agricultural building initiated in 1938 by Professor Renato Biasutti. Since 1950 publication has been accelerated but over half of the material has still to appear. As Dr. Saibene points out in the second of the volumes now under review, rural house types form a relatively stable element in the cultural landscape, being the result of secular adjustment. He himself covers the Lombard section of the North Italian plain and the morainic belt to the north. He gives a thorough, systematic account of the various types of dwellings and steadings on the agricultural holdings, his maps showing how closely the types correspond, in broad west–east zones, to soil conditions, while on the lower plain the sub-types are related to the dominant crops. This volume also contains much basic material on the *corte*, the most distinctive rural unit of the region, and hints of a further substantial contribution to the discussion of the much-debated problem of its origin when further research has been carried out, especially on documents prior to the sixteenth century. Meanwhile Dr. Saibene suggests in a modest footnote that the *corte* in its original closed type is not merely a particular form of "enclosed space" but may have had a "binding and isolating function" in the feudal order of agriculture corresponding to that of the cloister in the monastic orders that pioneered so much agricultural progress on the irrigated section of the Lombard plain where the *corte* in its fundamental single-holding type is still found. Much comparative research on the historical geography of similar forms elsewhere in Europe remains to be done and Dr. Saibene himself mentions possible instances in China and pre-Colombian Peru. The *corte* related to several holdings is suggested to have originated in emphyteutic lease of feudal lands. Forms other than the *corte* have developed on the more recently reclaimed land, such as the swampy and heath areas.

The volume on Umbria contains four separate studies on the north, the centre, the west and south, and the upper valley of the Nera. That on central Umbria by Professor Desplanques of Lille occupies half the space. This arrangement of separate

sub-regional studies within the volume presents some inconvenience to the reader allergic to cartographical jigsaws. In Umbria there is much that will be familiar to the student of Professor Biasutti's own volume on Tuscany. In his preface to the present volume Professor Biasutti draws attention to the urban origin of certain features of rural building in central Italy and suggests their connection with the share-tenant's obligation of residence on the holding, which led to the application of some of the capital accumulated by urban merchants to provision of greater comfort on the agricultural holding. He instances the abandonment of direct contact in the living quarters with the livestock and the development of the external stair to the family quarters above the cowshed as the idea of townsmen rather than of peasants. Professor Desplanques shows how the process of separation has been carried further. His studies in the Valle Umbra lead him to suspect the operation of other economic, social and psychological factors in the evolution of rural buildings in Umbria as well as the work of the agricultural holding, to which they seem imperfectly adjusted. He also devotes considerable space to problems raised by the peculiar distribution of the *palombara* or tower-like dovecot.

Together these two volumes reflect the fascinating diversity of problems raised by rural buildings in Italy. We may envy Italian geographers not only the rich regional variety of rural building types, which adds so much to the pleasure of travel in their country, but also the fact that with these further volumes published by the National Research Council yet another admirable project of research into the geographical, economic and social features of Italian agriculture is so far on its way.

C. J. ROBERTSON

HANDRITADE KARTOR ÖVER SVERIGE. Acta Bibliothecae, Vol. 10. By ÅKE DAVIDSSON. *Uppsala*, 1956. $10^{1}/_{2} \times 7^{1}/_{2}$ *inches;* 136 *pages;* 5 *plates*

The University of Uppsala is rich in materials of interest to the historical geographer. The appearance of this catalogue of the recently reorganized manuscript maps which are housed in the library gives further evidence of the wealth of its collection. Such catalogues are a most valuable aid to research workers who would know in advance of travel precisely what can be found in particular collections. In general, the manuscript maps at Uppsala belong to the period after the establishment of the Swedish Survey in 1628 and before the mechanical reproduction of maps in the earlier nineteenth century. Although they are commonly of independent origin, the maps are sometimes the work of the state surveyors and often the consequence of their collaboration.

Dr. Åke Davidsson's introduction to the catalogue (summarized in German) gives some idea of the way in which the collection has been acquired. It is the product of wise purchase as well as of generous gifts. Gifts of maps were already being made to the university in the seventeenth century. Acquisition through book auctions, the earlier of which produced catalogues which are social documents in their own right, has been the policy for fully two hundred years. The Palmskiöld collection, purchased in 1724, is a case in point. Of the number of private collections which have come into the library the Gyllenborg is among the most substantial. Some of the more obscure cartographical items, *e.g.* plans of projects which did not materialize, and mining profiles, have been omitted.

The first and most extended part of this catalogue of 1650 items divides the collection regionally into provincial maps, hundred maps, parish maps and town plans. The second part consists of special maps which cover frontier territories, highways, winter and summer routeways, mining tracts, river improvement schemes and canal projects. There is also a limited number of hydrographical surveys from lake and skerry coast. The quality of many of these maps can be appreciated from the five illustrative plates—one of them a town plan of Lund! The catalogue concludes with a register of surveyors and cartographers which is a ready index to the examples of their work in the university collection.

W. R. MEAD

THE NORTHERN SEA ROUTE AND THE ECONOMY OF THE SOVIET NORTH. By CONSTANTINE KRYPTON. *London: Methuen*, 1956. 8½×5½ *inches; ix+219 pages.* 21*s*

Mr. Constantine Krypton writes of 'The Northern Sea Route and the economy of the Soviet North' from the commanding position of an émigré who had access to Soviet planning data over many years. But his bureaucratic approach fails to infuse the subject with even a little of the romance which still surrounds the North-east Passage in the minds of Englishmen. He has nonetheless produced a mine of carefully documented information as a useful contribution in a little-known field. Mr. Krypton points unerringly to the "deliverance from foreign independence" implicit in the First Five Year Plan as having destroyed the economic basis of the Kara Sea Route. He is probably correct in his reference to ". . . the general Soviet policy to stress the peace-time aspects of projects which are of vital strategic importance." But he goes on to say flatly that "the real value of the Northern Sea Route to the Soviet Government lies in the transportation of military cargo in time of war." He does not even mention the great White Sea naval dockyard at Molotovsk in support of this contention and refers surprisingly to the "establishment" of the Polyarnoe base in 1933. Has Mr. Krypton really never heard of Port Alexandrovsk? It is not true to say that the Kola Peninsula was "cut off" by enemy action in the Second World War and the author, in all fairness, should qualify his statement that the Russians supplied ". . . the coal needs of (Arctic) convoys bringing in lend-lease supplies." I have a vivid recollection of despoiling the half-empty bunkers of a homeward-bound British freighter in the middle of the White Sea in order to keep the icebreaker *Lenin* still steaming. The human note is sadly absent from this study. One of Papanin's coarser stories would immeasurably lighten the mass of statistics, or a remark such as that of the Soviet admiral who, on hearing that the Spitsbergen coalfields were still burning in 1942, observed that the Polar bears ought by now to have turned brown. It is a pity that Mr. Krypton's useful and informative book should make such tedious reading. And how I wish he would not use that horrible word "cabotage."

ANTHONY COURTNEY

ASIA

BANARAS: a study in urban geography. By R. L. SINGH. *Banaras: Nand Kishore*, 1955. 10×7 *inches; 190 pages; map and illustrations.* 20*s*

Dr. Singh has applied to Banaras various techniques familiar to students of urban geography. It is interesting, for example, to see that Christaller's grading of towns appears to work in the *umland* of Banaras: rejecting other familiar terms such as "urban field," the author claims that this *umland* "forms a homogeneous socio-economic region," which could well be used as a planning unit. It is interesting also to see a plan of the town of the future with ring roads and even satellite towns: indeed, this makes the author's comparisons with Birmingham seem valid. But the main value of the work lies in its revelation of the land use of an Indian town, having some 70,000 people in domestic silk-weaving as well as smaller numbers in a variety of modern industries. As in western towns, a main shopping quarter has offshoots along various main roads, and the crowding of population in the central area is also familiar. Dr. Singh, writing sympathetically of the health conditions, tells a story rather like that told by Engels and later writers in British cities, and gives a useful map of the area liable to flood based on his own experience in relief work. On such points, he is more successful than in the discussion of physical features. There are some misprints, and many quaint turns of phrase as well as familiar "undergraduatese" like "with the advent of" or "in regard to." Many of the photographs are disappointing, and the index, not prepared by the author, is unhelpful. But the work should be welcomed for its vivid if in places artless impressions of the geography of a large Indian city. The book has an interesting dedication.

T. W. FREEMAN

CHINA'S CHANGING MAP. By THEODORE SHABAD. *London: Methuen*, 1956. $6\frac{1}{4} \times 9\frac{1}{4}$ *inches;* xv+295 *pages; maps and tables.* 32*s* 6*d*

Dr. Shabad's capacity for absorbing and summarizing an immensity of factual information will already be familiar to all who have read his earlier 'Geography of the U.S.S.R.' and, as he himself states, the present book, dealing with the political and economic geography of Communist China, has been conceived in the same image as its predecessor. In outline the work consists of three general and very substantial chapters, concerned respectively with the physical setting, the political framework and the economic pattern, and these are followed by thirteen regional chapters which, although individually much shorter, together make up the greater part of the book. With the exception of the physical introduction which makes no claim to be more than a résumé of familiar work on the subject (though in fact it is a model of compression and clarity), the material relates almost exclusively to the period since 1949 and has been derived from a wide range of Chinese and Russian, as well as Western sources.

The result of Dr. Shabad's prodigious researches is a book of quite exceptional value to all who are concerned to understand the nature and extent of the changes which the new regime has wrought in the economic and political geography of China. Notwithstanding a certain monotony in style and layout, particularly in the regional chapters, the bare facts which the book presents make compelling reading and the picture which finally emerges is remarkably clear and convincing. With a population which passed the 600 million mark in 1955 and is now growing at a rate of 12 million a year, and a resource base of continental proportions under their direct control, the Chinese Communists have embarked on an all-out drive to transform their country into a major industrial power. And although they themselves openly admit that the task will not be completed before the end of the century it is clear that if the present rate of advance is maintained in the industrial sector the new China will become a major force to be reckoned with long before that period is accomplished. In the meantime one suspects that Dr. Shabad's book will call for frequent revision, but it will assuredly be a long time before it is superseded as the standard work of reference on this all-important subject. C. A. FISHER

JAPANESE GEOGRAPHY: A guide to Japanese reference and research materials. By ROBERT B. HALL and TOSHIO NOH. *Michigan University Press; London: Cumberlege*, 1956. $8\frac{1}{2} \times 11$ *inches;* x×128 *pages.* 40*s*

This volume, the sixth in the Bibliographical Series of the University of Michigan's Center for Japanese Studies, consists of a carefully selected and briefly annotated list of 1254 books, atlases, periodicals and individual articles published in the Japanese language during the present century and dealing with various aspects of the geography of Japan. The classification seems eminently practical and all names and titles are given in both Roman and Japanese script. To those geographers who read Japanese it will doubtless prove invaluable as a guide to a surprisingly extensive range of literature. But for the rest of us who lack that facility, its all too brief summaries of the works which it lists will serve only to emphasize the disabilities under which we labour in seeking to analyse the Japanese scene. C. A. FISHER

LAND OF THE 500 MILLION. By G. B. CRESSEY. *London: McGraw Hill*, 1956. 10×7 *inches;* xv+387 *pages; maps and illustrations.* 56*s* 6*d*

A new book from Professor Cressey on the geography of China is to be warmly welcomed, and invites comparison with his earlier work on China's geographical foundations, published more than twenty years ago. 'Land of the 500 million' replaces the earlier book rather than supplements it. The changes are much greater than one would normally find even in a fully revised edition and may well justify a new title, of which the sentiment is unexceptionable but the accuracy doubtful. The extent to which it has been necessary to rewrite the earlier book bears witness not

only to the dramatic political, economic and social changes which China has undergone in the intervening years, but also to the growth of knowledge about China and changes in geographical method with which Professor Cressey has kept pace. Population and its problems are given greater stress and a prior place in the book, and urban and rural settlement are given a rather sketchy outline. A five-page historical summary (which includes a tabular representation of China's "cultural" development) outlines a necessary framework, but in the reviewer's opinion is not sufficiently integrated with the abundant and pertinent comments on the historical geography of China which are scattered through the rest of the book.

Many British geographers may also be troubled by the relative neglect of geological and structural background, though land forms are described and land form regimes well and carefully mapped. Air-mass analysis and a modified Köppen classification of Chinese climates represent a great improvement on the earlier book, and so also does a new section on hydrology with useful sections on problems of flood, famine and drought and current plans for water control and on the distribution of irrigation in China. Soils and the maintenance of soil fertility are basic considerations in agriculture as a whole, but one regrets the small amount of space devoted to both the interrelated problems of disease and health and also to recent institutional changes in agriculture. An inventory of mineral and power resources suggests a moderately good basis for future industrial prospects and the overwhelming need for better communications is graphically illustrated, though again some may regret the small amount of space devoted to the problems and character of Communist planning. The regional division of China follows the author's earlier precedent though the Outer Provinces are much more fully treated and there are other modifications. Regional descriptions are packed with information and useful ideas, though there is some repetition of matters previously treated in systematic chapters, and it is sometimes difficult to see on what basis some of the material has been allocated to one or the other. For instance, typhoon weather is twice described; information about iron and steel production at Anshan is found in three separate places, and partially repeated. Illustrations are new and excellent, with a lavish use of air photographs. There is scarcely any duplication between the illustrations used here and those in the earlier book. Statistics are as recent as possible. Maps are good and well selected, though maps of structure and of agricultural regions would have been welcome additions. There is a good bibliography.

C. T. SMITH

EAST OF EVEREST. By EDMUND HILLARY and GEORGE LOWE. *London: Hodder and Stoughton*, 1956. 9½×7 *inches;* 70 *pages;* 48 *plates.* 21*s*

THE SIEGE OF NANGA PARBAT. By PAUL BAUER. Translated from the German by R. W. Rickmers. With a preface by Sir John Hunt. *London: Rupert Hart-Davis*, 1956. 8½×5½ *inches;* 212 *pages; maps and illustrations.* 25*s*

NANGA PARBAT PILGRIMAGE. By HERMANN BUHL. Translated by Hugh Merrick. *London: Hodder and Stoughton*, 1956. 9×5½ *inches;* 360 *pages; maps and illustrations.* 25*s*

LE MEIJE. By HENRI ISSELIN. *Paris: Arthaud*, 1956. 8½×6 *inches;* 264 *pages; map and illustrations.* 1200 *fr*

Books on mountains are as diverse as the lands which produce them. The works of two New Zealanders, a German, an Austrian and a Frenchman, ranging from the Alps to the Himalaya, are likely to be a very varied feast. Sir Edmund Hillary and George Lowe write of the 1954 New Zealand expedition to the Barun Valley. Wisely, they have not overloaded with detail and have chosen a large format, allowing 70 pages of text against 48 of plates. This plan was most successfully adopted by Eric Shipton in his book on the Everest Reconnaissance of 1951, and is certainly very suitable for exploratory journeys. The pictures, looking well in photogravure, excellently illustrate the story, a straight and vivid account of an important piece of

exploration. Incidentally, the authors are to be congratulated on the placing and presentation of the diagrams, which occur just when the reader is beginning to want them. The journeys undertaken were wide and varied; but for most the highlights will be Hillary's dramatic and sincere account of the accident to Macfarlane, followed by his own illness, and George Lowe's description of Baruntse (23,570 feet), the fine ascent of which provided drama too. It is interesting that the writing (as climbing) styles of these two mountaineers are very close to each other; but perhaps that is because New Zealand styles are difficult for the Englishman to differentiate. There is a pleasing directness about both, and the seasoning of New Zealand humour.

Nanga Parbat is to the Germans very much what Everest has been to the British. Dr. Bauer has said the last word, or rather the last word but one, by giving in 'The struggle for Nanga Parbat' the mountain's whole history, from Adolph Schalgintweit's first mention of it in 1856, to the moment on 3 July 1953 when Hermann Buhl unrolled the Tyrolese flag upon its summit. Dr. Bauer has written the book we have come to expect from him: a mainly unemotional, straightforward and accurate history, with enough detail but not too much. The dramatic effects are gained by the situations themselves, which need no adornment. The picture of the Sherpa Gaylay dying beside his leader rather than go down in 1934, or of the 1937 party sleeping peacefully in camp and suddenly overwhelmed by avalanche destruction: these are drama unadorned. Two British parties move across the scene, Mummery's in 1895 and John Thornley's in 1950. Both ended in disaster. The book moves with increasing momentum forward to its climax, the astonishing feat of Hermann Buhl, who climbed the whole of the last long stretch to the summit alone. That achievement was marred by the quarrel between the leader and some members of the party; on this and on the leader, Dr. Bauer is brief and fairly damning. But he does not overpress that aspect. Rather he looks to the glory of the summit's winning as a whole, as the crowning last page of one great episode of Himalayan history.

This page is treated also by Hermann Buhl, whose lot it is to have the very last word of all. But absorbing as it is, and amplifying the quotations from his account given in Bauer's and Herrligkoffer's books, the story of 1953 occupies only the last 50 or so of 350 pages. The rest is what all climbers must long have been awaiting from the man responsible for more sheer astonishing ascents, particularly solo, than any other in the Alps. The theme of 'Nanga Parbat pilgrimage' can be summed up very roughly as "Beauty is challenge." I would not agree with those who think that Buhl would have performed the same feats, had the mountain scenery been absent. It was the mountains that acted as a drug almost, or intoxicant, compelling him to match their beauty with his own prowess. This means that I get a very vivid impression of the rock or snow texture that he is climbing; no picture at all of the mountains themselves as personalities, outside their storms or granite or powder snow, and little of other people; but a really fascinating study of a man with one purpose in life: to go further and higher and harder than he has ever gone before, to achieve what he and everyone else has considered impossible and even mad. Competition is with himself rather than others, and Buhl is kind to other climbers, though I suspect not really interested in them. The climbs described are taken at a fast pace, so that the reader, particularly if he knows the district, is staggered to find himself, for instance, solo at the top of the East Face of the Watzman in winter, almost before he has had time to take in the audacity of the undertaking. But it is hard to name the most arduous of these ascents. The lone climb up the North-east Face of the Piz Badile, after a cycle journey from Innsbruck and before a cycle journey back? The traverse of fifteen Chamonix Aiguilles in one expedition, with an adventure on the République thrown in as *hors d'oeuvre*? Or the North Face of the Jorasses, ending with a traverse in bad weather, on over the summits? It is an impossible choice. But of all the most startling is without doubt that final lone climb to the summit of Nanga Parbat, a climb unequalled in Himalayan records. The return journey brought sadness and dis-

agreement; but a spirit of forgiveness prevails which is not patronizing, and of reconciliation.

'La Meije' by Henri Isselin is a very different book. Instead of speeding from place to place, it is focussed on just one mountain of 13,081 feet in the Dauphiné. The Meije kept its summit inviolate twelve years longer than the Matterhorn, and the story of the early struggles upon its great rock buttresses are quite as gripping. After the first complete ascent in 1877 comes the filling in: first of the ridges, then of the various faces of the mountain down to 1951. Some of these will be of less interest to those who do not know it; but what will be of interest to all is the process, shown in miniature here, that is going on all over the Alps. From ridge to face, from big face to piton speciality. There is sadness, as well as truth, in the author's last reflection that the once "unclimbable" Meije should be now no more than a training ground for higher and harder things. Will that be said, one day, of Nanga Parbat?

WILFRID NOYCE

THE TRAIL OF MARCO POLO. By JEAN BOWIE SHOR. *London: Muller*, 1956. 8×5½ *inches; 251 pages; photographs and end-paper map.* 16*s*

"There is a pass across the High Pamirs, in the region called Wakhan. It is dangerous, and eerie, and awful. Marco Polo crossed that pass, and so did I. And one night I stood watch in a rude rock shelter on a snow field under the 20,000-foot summit while my husband, Franc, raved in fever. I knew that he was probably dying, and in his lucid moments he knew it too. In an atmosphere so thin that every movement required painful exertion of will and body, I gathered yak dung for our guttering fire. I melted snow and cajoled him to drink, and I bathed his parched skin."

These are the opening paragraphs of the book, and we have to wait until nearly the end to learn not only that Franc did not die, but that he had completely recovered his strength and appetite by the time they reached Misgar the following afternoon. We find too (page 201) that the "rude rock shelter on a snowfield" was situated well below the tree line and thus at an altitude of not much more than 12,000 feet. Through Asia Minor and Iran to Kabul and thence to Faizabad in northern Afghanistan, the "trail" was followed in mechanized transport, mostly lorry and motorbus. The author presents a straightforward, readable and often amusing account of the difficulties encountered on the way, though she tells us very little about the countryside and not much about its inhabitants. From the end of the motor road at Faizabad, they travelled on horseback through the Wakhan corridor with the intention of crossing the Wakhjir pass into Sinkiang. However, news of trouble in that province and the sight of Chinese soldiers patrolling the pass, diverted them and, crossing another pass to the south, they were strangely surprised to find themselves in the state of Hunza. The description of this part of the journey is ludicrously dramatic. The passage quoted above is a fair sample. From their map, the travellers identified the pass by which they crossed into Hunza as the "Delhi Sang," more than 20,000 feet high. There is in fact no saddle along this section of the watershed of more than 18,000 feet, and it is probable that they mistook Dehil Sang-i-Sar (a triangulated peak of 20,424 feet) for the name of a pass.

ERIC SHIPTON

VOYAGE DANS LE SUD DE L'IRAN. By K. LINDBERG. *Lund: C. W. K. Gleerup*, 1956. 9×6 *inches; 331 pages; maps and photographs*

In this interesting book Dr. Lindberg describes a journey through the little-known and (then) poorly mapped part of Iran lying between Bushire and Assalou (Naband) on the Persian Gulf, and thence north to Firuzabad. The journey lasted three weeks and took place in 1940. Its purpose was to discover the western limits of the distribution of the Guinea-worm in south Persia, and the book records the results of Dr. Lindberg's enquiries into the occurrence of Guinea-worm infestation, and the locations at which he was able to collect specimens of the crustacean, cyclops, in which the embryos of the worm develop.

The author describes the villages that he passed, with brief comments on the

number, race and occupation of their inhabitants, and some more general notes on local relief, agriculture and trade. He has also summarized several earlier records relating to the same area, and has drawn attention to cartographic errors on the maps of the area then in common use.

This book will provide convenient background reading, and a historical record, for anyone wishing to study parts of the area in detail. It is not sufficiently informative to be of great value by itself. Dr. Lindberg obviously holds strong views about the motives behind, and the consequences of, British–Indian influence in Persia and the Gulf. Some of his accusations are surprising, one or two are rather naïve, but a few passages of this nature do not detract from the value of the book as a whole. There are some good maps, and several photographs, which are disappointing.

P. H. T. BECKETT

THE BORNEO STORY. By HENRY LONGHURST. *London: Newman Neame*, 1956. 9½×7 *inches; 120 pages; illustrations and endpaper maps.* 15*s*

In the November of 1839 James Brooke, later Rajah of Sarawak, wrote from Singapore to the Society's Secretary, Captain Washington, an account of the *Royalist's* first visit to Borneo. "The time was chiefly engaged in boating excursions," states Brooke calmly, ". . . ascending many of the rivers and laying them down as accurately as we could. . . . The Sarawak river we ascended 100 miles until it was not above 20 feet across. My progress was principally obstructed by a rebellion in the interior which prevented my gaining the mountains, but this cause once removed I entertain no doubt I can with ease penetrate 200 or 300 miles inland. . . . I have been domesticated with the Sibuyaw Dyaks for a fortnight and have become well acquainted with their manners, customs and household economy—their long room was no less than 600 feet from end to end." Thus the eternal explorer, discovering the land; behind him come the trader, the missionary, and eventually the official administrator. Brooke and the handful of Europeans who were attempting, more or less as a hobby, the civilization of Sarawak, were joined in 1851 by Ludwig Helms. Helms was an enterprising Dane who was the first agent of the Borneo Company Ltd., formally established in 1856 with offices in Singapore and a programme for the mining of Sarawak's antimony, gold and coal. The Company celebrated its centenary last year, and this entertaining and well written account of its first hundred years has a foreword by Sir Charles Vyner Brooke, the last "White Rajah." From small beginnings the company's activities spread all over the Far East. Flexible and far-seeing from the first, its directors have lost no chance of developing the virgin resources of Borneo, Malaya, Siam and of what is now Indonesia; there has even been a recent venture in Canada. Minerals of various kinds, rubber, tea and timber have all been grist to the Company's mill, and it is now in a position to "sell you anything from a teak log to a box of matches, a barge to a bottle of beer; [to] insure you, book you an air passage, victual your ships, or act as your agent whatever country you may live in and whatever you want to sell." Among the host of gallant, eccentric, capable and romantic characters which crowd Mr. Longhurst's delightful narrative, stand out the colourful James Brooke, Anna Leonowens, introduced to King Mongkut by the Company, her rolling-stone of a son, Louis, who had a hand in opening up Siam's teak forests, and the appealing little white elephant born in the Company's lines in 1926 and presented with great ceremony to the King and Queen of Siam.

DOROTHY MIDDLETON

AFRICA

THIS IS YOUR HOME. By KATHLEEN WALLACE. *London: Heinemann*, 1956. 8½×5½ *inches; 168 pages.* 16*s*

I PRESUME. By IAN ANSTRUTHER. *London: Bles*, 1956. 9×5½ *inches; 167 pages; illustrations and map.* 18*s*

No two explorers could differ more widely than Mary Kingsley and H. M. Stanley, and yet both made an impression on unknown Africa by dint of the same virtues of

courage, competence, and that mysterious quality of genius which defies analysis. But the paradox does not end there: unlike each other, they were both within themselves a contradiction. Mary Kingsley, superficially all the Victorians called a "lady," was always unconventional and sometimes inspired, besides being an agnostic unacquainted with the Bible; Stanley, the deprived child who by all the rules should have grown up a delinquent, achieved his astonishing successes by stern attention to duty and to method, and by simple faith in God.

The two books under review by no means provide the last words on these two exceptional people, but both have points of interest and are worth reading. Kathleen Wallace calls hers "a portrait of Mary Kingsley" and interleaves pages of known facts and direct quotation with imaginary scenes in the manner of that modern hybrid the "fictionalized biography." Mrs. Wallace is, however, an experienced novelist and the result is surprisingly successful. Mary Kingsley, the dutiful daughter, emerging from one of those cold, grey, Cambridge houses; Mary Kingsley the West Coast trader piloting a 2000-ton vessel up the treacherous creek; "devil-hunting" round a dishevelled bedroom to appease the victim of delirium tremens; drinking endless cups of tea; walking through the swamps with umbrella in hand and pill-box hat firmly tied under her chin; honoured by the rough traders of "the Coast" for her quiet efficiency and astringent humour—yes, Mary Kingsley comes to life all right in Mrs. Wallace's slight volume.

Ian Anstruther tells the story of Stanley only as far as 1873, and his theme is that the explorer, at any rate in these early years, missed the acclaim due to him because of his social gaucherie. His touchiness alienated those who should have most warmly supported him, and his famous "Dr. Livingstone I presume?" became a joke. It is, of course, well known that the Society's reception of Stanley fell short of what he expected, and Mr. Anstruther makes perhaps rather too much of this. Owing to his laudable desire to be fair to both sides the picture is a little blurred: impartiality does not make for vividness. On the whole the case is argued well and a possible interpretation of Stanley's baffling personality is sensibly presented. There have not been many books about this most important figure in the history of African exploration, and it is to be hoped that readers of 'I presume' will be encouraged to turn to Stanley's own autobiography and to his great books on Africa. DOROTHY MIDDLETON

AFRICAN TRAVEL

As a "popular" account of what was evidently a "serious" expedition, MM. Berrier and Denizet's HIGH PLACES OF AFRICA (*Hale*, 1956, 18*s*)—despite some very flat conversation and an excess of exclamation marks—is a model of its kind. The route the expedition followed in the winter of 1952–3 was Algiers–Tibesti–French Equatorial Africa, thence via Stanleyville–Ruwenzori to Nairobi–Moyale–Addis Ababa and Lalibella, and they claim to have made the first motor-car link between Tasili and Tibesti. Although both are members of the Paris Société de Géographie, their expedition was mainly concerned with ethnology and archaeology, and the book contains some impressive photographs of Lalibella and the frescoes.

The photographs in Barbara Toy's A FOOL IN THE DESERT (*Murray*, 1956, 18*s*) are on the other hand all centred round people and things, and it was the people she met who now stand out in this account of four journeys by car in Libya (including Kufra). Interested in everything, from *grafitti* in a deserted barracks to diving in Benghazi harbour, Miss Toy evidently has a gift for making friends and for skilful characterization, which a novelist might envy, when she comes to writing about them afterwards.

Like Charles Doughty, John Skolle "trusted his existence among unlettered and reputed lawless tribesfolk" when he joined a camel caravan in the western Sahara in 1955. His account of a 450-mile journey from the salt pans of Taoueni to Timbuctoo (THE ROAD TO TIMBUCTOO, *Gollancz*, 1956, 18*s*), on a much tinier scale, is at times reminiscent of 'Arabia Deserta,' particularly when we read of the rashes, ulcers,

palpitations and loss of weight which afflicted Mr. Skolle on the journey, even though he was supplied with disinfectant tablets, toilet paper and "pudding powders." The final section of his book provides an interesting sidelight on day-to-day life in Timbuctoo while Mr. Skolle also gives a useful account of the Sahara salt trade.

Dr. Andras Laszlo, an American citizen, spent six months in Angola in 1953, and his DOCTORS, DRUMS AND DANCES (*Hale*, 1956, 18*s*) is an account of his investigations into tropical diseases and primitive customs in the area. As a doctor, the author looks at Africa from a new angle, and his observations on "black magic" in terms of medicine are unusual. His chapter on leprosy is particularly memorable. DAVID WELSH

NORTH AND SOUTH AMERICA

UNITED STATES AND CANADA: a regional geography. 2nd edition. By ALFRED J. WRIGHT. *New York: Appleton-Century-Crofts*, 1956. xviii+290 *pages; maps and illustrations*. $7

This second edition of a book first published in 1948 adds another to the company of admirable text-books of the regional economic geography of North America.

Perhaps this book makes even less pretence than usual of dealing with any but the economic aspects of the regional geography which is its subtitle. It does, however, by way of compensation treat its economic geography relatively seriously. There is an abundance of well-selected and relevant statistical tables, many pages of careful and interesting description of agricultural and industrial landscapes. It can be used for reference more readily than most text-books.

The four general chapters on agriculture, minerals, industry and commerce are however disappointing. As in many books of this type, no appeal is made to the readers' intelligence. They contain little analysis of technology, and mainly consist of summaries of information from the regional chapters. Foreign trade receives very scant treatment, amounting to little more than two or three tables of figures and the simple-minded sentence: "Periodically the Congress is forced to decide how much additional import trade is to be permitted in order that the productivity and strength of friendly countries may be increased."

The book is very poorly supplied with maps, but over-abundantly with well-reproduced photographs. Like his fellow text-book writers the author appears to assume that a section of his readers look at nothing but the photographs, and therefore takes the opportunity of inserting under each one a piece of information the proper place for which is in the text, and which does nothing to explain or give significance to the picture. Thus Figure 7–7, of some piece of undescribed machinery in the Bristol Brass Co., Connecticut, bears the caption "The nonferous industry ranks high in New England." A large number of the photographs, particularly those of factories and machinery, do very little if anything to deepen the reader's appreciation or understanding of the landscape or the economy. Had two-thirds of the money and and time spent on them been devoted to additional maps and diagrams, and to a more analytical and technological approach to the subject matter this book would have been more interesting and more worthy of the university student for whom it is designed.
A. F. MARTIN

THE NORTH AMERICAN MIDWEST: a regional geography. Edited by JOHN H. GARLAND. *New York: Wiley; London: Chapman and Hall*, 1955. ix+252 *pages; 80 maps and diagrams*. $8 (64*s*)

The geographical literature of North America though rich in well produced text-books on the geography of the continent as a whole, including those dealing with it region by region, is nevertheless surprisingly poor in substantial geographies of its major regions. To some extent this gap has been recently filled by the publication of Putnam's Canadian Regions, but for the United States one can recall only three or four, such as Parkins on The South, Freeman and Martin on the Pacific Northwest,

and possibly the American Geographical Society's cooperative work on New England's Prospect.

This book on the Middle West, the work of sixteen specialists each contributing on a special topic or sub-region, is to be welcomed as a sign that American authors and publishers appreciate this lack. And those who turn to it for this reason will not be disappointed. Like many other regional geographies the book includes some general chapters (90 pages) and then a region by region account (150 pages); there are also a short bibliography and an index. The general chapters are no mere repetition of the descriptive accounts of farming and industry which are the mainstay of the general text-book, nor are they just a summary of the regional chapters which follow in which the necessary facts are given in a fairly full form. Each general chapter gives a thoughtful analysis of the material with which it is concerned. The interesting chapter, for example, on Structure of Industry deals with distribution of manufacturing as a whole, area specialization, degree of industrialization in different areas, broad types of manufacturing and their distribution. The first chapter, too, is a bold and stimulating attempt to grasp the individuality of the Middle West not only within the United States but in relation to the world, and to understand its character as the most important of the great Sections of the U.S.A.

Some things, however, will strike the English reader as odd. Climate is given its share of attention (a general chapter as well as a paragraph or two in most of the regional chapters); some notice, too, is taken of soil groups; but other aspects of physical geography, and particularly relief and geology, are almost ignored. There are many maps in the book, but none of relief or geology. This neglect is a serious and obvious deficiency. The maps suffer badly from what seems to be an American habit of over-reduction along with great clarity in other respects. The large folding map of road traffic flow (Fig. 38) is quite illegible. Full footnote references are given in some chapters, but in others are none at all.

Most, however, of these defects are minor. The book gives a very valuable and interesting, even if to our minds rather lopsided, account of probably the most difficult and certainly the most important of the regions of North America. A. F. MARTIN

TOWN AND COUNTRY IN BRAZIL. By MARVIN HARRIS. *Columbia University Press; London: Oxford University Press*, 1956. 9×5¾ *inches;* x+302 *pages; maps, tables and illustrations.* 36*s*

This is sociological research at its best, based on intensive field work and explaining every facet of the human components of Minas Velhas, a small Brazilian town set high and isolated in the mountains of central Bahia. This urban survival of the eighteenth century mining boom formed the nucleus of a community study by Dr. Harris and three Brazilian students under the joint sponsorship of Columbia University and the state of Bahia; and it has also produced a picture which conforms to neither foreign nor Brazilian stereotypes of such settlements in the highland interior of that vast country. Every aspect of the cultural landscape of the town and its rural surroundings is dissected carefully and thoroughly. The economic basis, the impact of class and race, the parts played by the individual, the family and the government, and the influence of religion and folk belief are all framed within an excellent introductory chapter on the physical setting of the *municipio* and the historical growth of its settlements. While much of the detailed material is primarily of interest only to the cultural anthropologist, it is the superbly written final chapter of conclusions synthesizing the rural-urban dichotomy of this pre-industrial urban unit and its village satellites which will appeal most to geographers. Indeed no student of urban geography can afford not to read this penetrating study of an urban culture in a remote environment pre-dating yet out-dating the industrial revolution. It is because the study has more than a local or a regional significance as exemplifying the remarkable strength of the urban complex in Latin America (the origins of which Brunhes recognized nearly forty years ago) that this book will be welcomed by both laymen and

specialists. There is much incidental information on a little known area of Brazil, much which brings into vivid relief the paradox of an old town in virgin and practically unexplored wilderness, and much which gives an intimate insight into the sociological pattern of Latin American life which (except for some two dozen metropolitan cities) is the typical background of the human geography of the continent.

G. J. BUTLAND

LATIN AMERICAN TRAVEL

By chance the first two books to be reviewed here are concerned with the same subject —diamond prospecting in the hinterland of British Guiana. They are strikingly different. In BEYOND THE HIGH SAVANNAHS (*Longmans, Green*, 1956, 18*s*) James Wickenden puts into readable prose the experiences of a West Indian "pork-knocker" (the free-lance prospector). The story is convincing and the events credible. The wild life does the normal things, there is the occasional snake and the Indians do little that would disturb a Victorian moralist. The book would have profited from a map, and when the conversation lapses into the vernacular it rapidly becomes incomprehensible. Fortunately this last does not often happen and there are few blemishes to an interesting and sympathetic account.

Victor Norwood, the author of MAN ALONE! (*Boardman*, 1956, 18*s*), was himself a "pork-knocker" and his adventures were truly remarkable. Attacked by bandits and alligators, bitten by a spider, he meets vice, violence and squalor on every hand. So monotonous does the savage and the sordid become that the reader's attention turns to the author rather than the text. Interest in him heightens when he describes a plant "with long, restless tendrils" which catches and feeds on sizeable birds; the British Museum (which is said to have given him some commissions) would certainly have been interested in specimens of this novelty! The author expresses his intention of returning to Guiana for another expedition; in view of the disturbances which his presence seems to excite and the miserable fate of his assistants, it might be better for all if he stayed away.

In a very different category is TUPARI (*Bell*, 1956, 18*s* 6*d*), Franz Caspar's account of the Tupari Indians of the Mato Grosso, translated by Eric Northcott. The original German edition has already been reviewed in the *Journal* for September 1954. It is very good to have an English translation of so notable a book, but sad indeed to have the brief and tragic postscript. Since the original edition, Dr. Caspar has revisited the tribe and found it reduced by illness brought in by rubber gatherers and the old pattern of life shattered. Can nothing save the tribes of the Mato Grosso from disintegration and decay as "civilization" pushes into their territories? PETER BELL

PACIFIC

ISLANDS OF MEN. By COLIN SIMPSON. *Sydney: Angus and Robertson*, 1956. $9\frac{1}{2} \times 6\frac{1}{2}$ *inches;* viii+248 *pages; sketch-maps and illustrations.* 21*s*

THE LAST CANNIBALS. By JENS BJERRE. Translated from the Danish by Estrid Bannister. *London: Michael Joseph*, 1956. $8\frac{1}{2} \times 5\frac{1}{2}$ *inches;* 192 *pages; maps and photographs.* 21*s*

ADVENTURES IN PARADISE: Tahiti, Samoa, Fiji. By WILLARD PRICE. *London: Heinemann*, 1956. $8\frac{1}{2} \times 5\frac{1}{2}$ *inches;* xii+245 *pages; sketch-maps and photographs.* 21*s*

GREEN KIWI. By TEMPLE SUTHERLAND. *London: Michael Joseph*, 1956. 8×5 *inches;* 240 *pages.* 15*s*

The first three of these books come under the general heading of travellers' tales: Mr. Bjerre is a traveller (and film maker) who writes; Messrs. Simpson and Price are writers who travel. All three are writing for the "armchair traveller," and offer him similar mixtures of personal adventures, "popular" anthropology, anecdotes and information, gathered from people they have met and from a variety of published

sources. Of the three, Simpson's 'Islands of men' is the one most likely to command serious attention from geographers. Two of the six parts into which the book is divided deal with New Guinea, the setting of two previous books by Mr. Simpson. One part describes a journey on the Sepik River while the other deals with the so-called "Shangri-La" valleys in the Central Highlands. By collating the reports of several expeditions into this remote and difficult area, Mr. Simpson is able to give his readers a perspective view of discoveries which were widely publicized in 1954. He flew over the Lavani Valley and took some colour photographs, which are reproduced. The valley is enclosed by very steep walls and much of its floor is occupied by lakes. It is drained by a river that disappears underground. The floor must be about 7000 feet above sea level, and the climate is likely to be uncomfortably cool for the scantily dressed tribesmen. The population of the Lavani Valley must be well below the figure of 100,000 quoted in early press reports.

In another section of his book Mr. Simpson launches a bitter attack on the Anglo-French Condominium rule in the New Hebrides. The "hoary gag" about the "Pandemonium," could hardly be further from the truth, he claims. "The atmosphere is one of somnolent official rectitude laced with routine official concern for British and French dignity. Nobody in official circles raises any hell at all. If only somebody did!" Mr. Simpson goes on to do just that, and his solution is simple, but drastic. Australia should take over Britain's share in the Condominium, lay the problem before the United Nations with a request that the islands should be made a Trusteeship Territory, and then buy out French interests in the group.

Mr. Bjerre's book describes his travels in New Guinea while making the documentary film of the same name which won a prize at the Edinburgh Festival of 1956; as a maker of geographical documentary films this author is in the highest class, but as a writer perhaps less impressive. Mr. Bjerre also describes a visit to Ayers Rock in Central Australia, and his experiences while living with a tribe of aborigines in the Yendumu Reserve. One chapter of this section is entitled "Bloody ceremonies in the desert: Native love life," and its themes recur throughout the book.

Willard Price's book reveals a similar preoccupation with the more "romantic" aspects of life in Polynesia. It is written in the form of a journal and describes a leisurely journey through Tahiti, the Cook Islands and Samoa to Fiji. There, like Colin Simpson, he saw the fire-walking ceremony, but he is more willing than Simpson to accept a glib explanation of how it is done.

The fourth book, 'Green kiwi' falls into a different category, that of pioneers memoirs. Mr. Sutherland emigrated to New Zealand in the 1920's and his book is a light-hearted account of his adventures over a period of ten years or so. He moved about, from job to job, gaining experience, and, by a lucky chance, visiting three areas that were still in the pioneer stages of development—North Auckland, the Wanganui "Inland" and the upper Buller valley. He went to the last of these shortly after the Murchison earthquake of 1929 and gives a vivid account of the scenes of destruction. Mr. Sutherland is extremely easy to read, and his book deserves a wide circulation. His sense of humour is delightful, his use of the New Zealand vernacular apt and impeccable, and his powers of description admirable. 'Green kiwi' is a most welcome addition to New Zealand literature. J. S. DUNCAN

POLAR

FRANKLIN, HAPPY VOYAGER. By G. F. LAMB. *London: Benn*, 1956. 8½×5½ *inches;* vii+282 *pages; illustrations, maps.* 35*s*

Two principal reasons are offered by the author for having written this book. Firstly, Sir John Franklin is remembered chiefly because of the tragedy of his last Arctic expedition, not because of his previous explorations, which were his greatest achievements. Secondly, the last biography (that of H. D. Traill) was published sixty years ago and is out of print, and since then some new material has appeared.

The book, which is pleasantly produced and clearly written, is divided into five parts, of which the first three concern Franklin's early life, his services as second in command to Buchan in the 1818 Arctic expedition in H.M. ships *Dorothea* and *Trent*, and his two overland journeys to the North American coast. The fourth part deals with his services in the Mediterranean and his governorship of Tasmania, and the fifth with his last expedition, during the course of which he died. Full use has been made of new material in describing Franklin's short married life with his first wife, and his unfortunate experiences in Tasmania. For geographers, the chief interest of Franklin's career centres around his Arctic work, and on this subject the author in his preface makes no mention of research amongst unpublished sources (such as the Admiralty records in the Public Record Office) and appears to have relied entirely on printed material. The bibliography enumerates only the "principal books consulted" and does not mention any "Arctic" Parliamentary Papers. This omission is surprising, for some of these are the only authoritative published sources for much of the information contained in the fifth part of the volume. Detailed references are not given.

A close scrutiny reveals weaknesses. Statements given as quotations or indicated as such by inverted commas are by no means invariably exact copies of passages in original sources, some of which are not mentioned in the bibliography; and the fifth part of the book is disfigured by additional inaccuracies. A conspicuous example concerns some of Rae's explorations, several of the author's assertions being at variance with Rae's own published reports. Some of the inaccuracies in this part of the book suggest, rightly or wrongly, that original sources have not been sufficiently consulted, and that the author has been content to accept as correct, without investigation, the statements (and some of the oversights) of others, as he has done when, in a summary of another writer's views, he has included without comment the erroneous statement that the figurehead of the *Investigator* is not now known.

Seventeen good illustrations and three maps of only mediocre quality are included. The map named "The end of Franklin's last voyage" needs revision. The positions marked "ships abandoned" and "record" should be placed more accurately, and those assigned to Parker Bay and Fury Beach are erroneous. There is a good index. Whether the new material published during the last sixty years is of sufficient importance to require an entire biography is debatable; but even if the need is admitted, the present biography does not exhibit all the qualities that commend themselves to geographers.

R. J. CYRIAX

ANTARCTIC VENTURE. By MARIO MARRET. *London: William Kimber*, 1955. 8½×5½ *inches; 218 pages; illustrations.* 18*s*

'Antarctic venture' is the leader's story of the fourth summer and third winter spent by French expeditions in Terre Adélie, under the direction of M. Paul-Émile Victor. During the visit of the relief ship *Tottan* the main base of the expedition at Port Martin was burnt down, and, rather than abandon a season's work, M. Marret and six companions decided to winter at the auxiliary base planned on one of the small ice-free islands, 40 miles west of Port Martin. It can only be said of the climate that it was a little less severe than at the old base, but blizzards were frequent and savage.

The scenic descriptions are what we have come to expect in an Antarctic book. Penguins are so often "odd creatures like dwarf clerics in black cassocks" that it would be refreshing to read elsewhere of clerics "like giant penguins"! Such descriptions are old stuff, and the discerning reader will look more for the reactions of the men to the test of their environment. In this book he will not be disappointed. On the mid-winter journey to the old base, justified only by the necessity to recover equipment for the survey work, Marret and his party showed the same courage and resource as their predecessors who dared the unknown (in Scott's words) "to wander forth in the depth of a Polar night to face the most dismal cold and the fiercest gales in darkness." But it is inaccurate to write of "six months of polar night" (p. 32) in

lat. 66° 40′ S. On a further technical point, Shackleton reached a height of 3280 *metres*—not feet (p. 148)—on the polar plateau.

Occasional obvious clashes of personality are drawn with restraint and understanding. There are convincing sketches of individuals and good accounts of the work on penguins by Prévost and of the survey journeys by the author, Dovers—the Australian observer on the expedition—and others. The journeys bring out the extreme hazards of Antarctic sea ice travel, especially in this region of high winds which can replace safe-looking ice by open water in a few hours. On the longest journey the party were away forty-three days, which included thirty-five days of blizzard.

The photographs are good, but the map does not show the region traversed on the western journey to the border of Terre Adélie, and the reader is left guessing where the elusive Rock X and Glacier Z, objectives on this journey, are situated. This is a well-written book about some valuable scientific work with limited facilities. The author modestly claims for himself the title of "polar technician," but his book and his film on penguins show him to be much more than that. G. HATTERSLEY-SMITH

ANTARCTIC HAZARD. By W. Ross COCKRILL. *London: Frederick Muller*, 1956. 8×5 *inches; 230 pages; illustrations. 15s*

The author, a veterinary surgeon, is appointed adviser to a whaling company in obtaining several thousand tons of whalemeat fit for human consumption, and his book tells the story of the 1948–9 season when he was attached to the *Southern Venturer*, a 23,700-ton factory ship, working out of South Georgia. He writes easily and with pleasing humour, spicing the story of his day-to-day job with anecdotes and rich character sketches of hardy, independent whaling men, hailing from Shetland, Norway and Scotland. The chief engineer who knew his Burns; the heavily tattooed laundryman with a taste for gin; the boilermaker, said to be the oldest British whaler, who also played the accordion; the famous Owner, ruthless and aggressive, who talked only of whaling and worked half as hard again as anybody else—the reader is introduced to them all. The reader is also taken aboard the veteran merchant ship, *Polar Chief*, which carried troops to the Boer War, Dr. Crippen to America and now serves as a depot ship in South Georgia. Whalegunners are some of the most reactionary men in the world. New ideas take hold slowly, or not at all, so it was only by exercising great tact that the author was able to enlist any cooperation from them in treating the whalemeat for human consumption. Unfortunately the subsequent story is one of ineptitude and bad publicity on the home market. To add to the author's difficulties, whaling men are very superstitious and believe that passengers on board bring bad luck. They do not allow umbrellas in the ship, detest cameras and never mention horses! The biologist should find a good deal of interest in the sections on the anatomy, breeding and pathology of the whale. It is probably true that whales are unlikely to be fished out, for the whaling companies would go out of business long before that happened. But it is surprising to hear that hunting whales increases their fertility. Surely the post-war years, after the whales had enjoyed a respite from the hunt, were boom years for the industry. The photographs are good, and there are very few misprints, but does the thermometer really drop to "fifty below" in a whalecatcher? G. HATTERSLEY-SMITH

BIRTHPLACE OF THE WINDS. By TED BANK II. *New York: Thomas Y. Crowell*, 1956. 8×5½ *inches; 274 pages; maps, illustrations and drawings.* $4.50

In the summer of 1948 the author went with one companion to the Aleutian Islands to investigate the burial caves, on one of which he had accidentally stumbled when stationed on the islands during the war. Other objectives included a collection of plants and a study of the native customs. The expedition was sponsored by the University of Michigan; military transport was obtained. The author writes in a racy style, with frequent passages of dialogue, which on the whole give the book an

engaging freshness. He becomes trite when he relapses into monologue, as when he finds his first cave—"Boy oh boy! what in the devil have I found?" The reviewer wonders which university professor in England would care to be dubbed "a chubby, white-haired old gentleman in a rumpled gray suit," as is the professor from Michigan, to whom the book is dedicated. Mr. Bank, whose companion left for a job on the mainland after two months, visited many of the islands by sea, but such is Aleutian weather that only tantalizingly short stops were usually possible. The most interesting finds were made on Kagamil, where the cave burials were first studied by Dr. Aleš Hrdlička of the Smithsonian Institution in 1937. The author dug up the false floor of one cave and brought to light a number of mummies, the oldest of which had a radio-carbon age of 950 years. The mummies found by Hrdlička at the higher levels were believed to be about 500 years old; there were reputedly no more burials after 1741, when the Russians first arrived and started to Christianize the Aleuts. Mr. Bank is clearly a very likeable person, and after the initial shyness was well received by the Aleuts, though not without remarks like "Hi! you more 'doctors' come to study us?" or "What you think we still native or something?" The picture which emerges of the Alaska native service is not very flattering. The reviewer is unable to judge the validity of the criticism, but recalls similar charges laid against those in authority over Eskimos, though the facts are often distorted. The book is well illustrated, and may be recommended to anyone interested in these islands where a dying native culture, on which eighteenth and nineteenth century Russian influence has left its mark, is confronted by the full force of western civilization.

G. HATTERSLEY-SMITH

ARCTIC TRAVEL

THE LAST KINGS OF THULE (*Allen and Unwin*, 1956, 21s) is an account of a year spent among the Eskimo of northern Greenland. Jean Malaurie, geographer on the French expeditions of 1948 and 1949 to Greenland, had been so attracted by the mixed natives in the south that he determined to return one day and visit members of the tribe who lived in the far north, isolated from European influences. In 1951 he succeeded in amassing sufficient financial backing for a one-man "mission" to survey the plateaus of Inglefield Land and Washington Land. His base was at Siorapoluk, "the pretty little sandy shore," a cluster of nine huts 125 miles north of Thule, and 60 miles south of Etah. There he tells how the Eskimo hunters and their families gradually admitted him to intimacy through endless winter visits, told him their folk-lore and taught him to hunt bear and walrus. In early spring and summer they accompanied him on his long survey journeys. M. Malaurie is deeply concerned with the future of the Eskimo. He writes of his friends with love, but also with some irony, for he appreciates both their virtues and weaknesses, and is never sentimental about them. The book is admirably translated by Gwendolen Freeman, and is illustrated by maps, drawings and a number of excellent photographs.

Katharine Scherman's book SPRING ON AN ARCTIC ISLAND (*Gollancz*, 1956, 18s) describes a six weeks' holiday on Bylot Island in the Canadian Eastern Arctic. She and her husband, amateur ornithologists, accompanied a scientific party there, and she enjoyed herself immensely. Nothing of note happened to them and the occasional attempts to explain the scientific objects of the party are hardly impressive; nevertheless one shares her pleasure in what she calls "the three outstanding facts of arctic life—the total lack of time sense; the fundamental laziness . . . and the vast, unending sociability." One is also impressed at the number of plants and insects that survive the Arctic winter as far north as Bylot Island.

Robert Marshall was one of those happy beings whose work and interests coincide. He was a member first of the U.S. Office of Indian Affairs, and then of the Forestry Service, and both these positions led him to places and occupations he loved. During the 1930s he made four long trips to the Brooks Range in northern Alaska, surveying the little-known northern Koyukuk river drainage area and climbing peaks of the

Arctic Divide. After his early death his brother, George Marshall, produced from the journals and letters he left, ARCTIC WILDERNESS, an account of his happy wanderings (*University of California Press*, 1956, 28*s*). Fortunately the author is able to pass on a measure of his exuberant enjoyment, as well as some pleasant pictures of the Alaskans with whom he journeyed, and the places they saw. The photographs are excellent and there are several useful maps illustrating the journeys. This is altogether a most attractive book.

Ejnar Mikkelsen's autobiography, which appeared in Danish as 'Ukendt man tel ukendt land,' has now been translated by Maurice Michael and published by *Rupert Hart-Davis* (1956, 18*s*) as MIRAGE IN THE ARCTIC. It was reviewed in the original Danish version, in the *Geographical Journal* of June 1955. L. M. FORBES

PHYSICAL AND ECONOMIC GEOGRAPHY

JURASSIC GEOLOGY OF THE WORLD. By W. J. ARKELL. *Edinburgh: Oliver and Boyd*, 1956. 10×6 *inches;* xiv+806 *pages; plates.* 105*s*

Dr. Arkell, who distinguished himself early in his career by writing the only modern, comprehensive account of a single geological system (the Jurassic) in Great Britain, has now given us the first book in which a single geological system is described on a world-wide scale. It is, of course, primarily a work of reference, but the first thing to emphasize is that this book is *written*. In spite of the prodigious number of facts contained in it, and the wide range of sources used, this is not a mere compilation or a string of quotations from the sources, but a readable account by an author who has first digested his material.

The book falls into three sections: in the first, the principles of correlation within the Jurassic system are explained, with tables of the subdivisions employed; the next, and longest, section systematically describes the nature and distribution of Jurassic rocks throughout the world, much attention being paid to stratigraphical correlation by ammonites. This aspect is especially valuable to the geologist, since many of the correlations are founded on the personal assessment of monographed faunas, or actual collections, by Dr. Arkell. The descriptive part of the book is arranged according to geographic regions, each area being dealt with under headings corresponding to the stages into which the Jurassic is divided. A valuable feature of this part is the abundance of maps showing the distribution of Jurassic outcrops.

In the last part of the book the author has attacked such problems of general interest as the permanence of the oceans, past climates, and the distribution of mobile belts and stable areas, in the light of evidence provided by the Jurassic rocks. There is an exhaustive bibliography (said to contain over 2800 items) and half-tone pictures of all the zonal fossils.

The geographical reader should perhaps be warned that Dr. Arkell has eschewed palaeogeographical maps. He was probably right in this decision, for while in certain cases they may be fairly accurate for small, well-known areas, such as the British Isles, when drawn for continents or hemispheres they involve so much uncertainty that they are of little value, being of no use to the expert and giving a misleading impression of accuracy to the unwary.

The book should be useful to all who have occasion to inform themselves on the geology of a particular region, or who are travelling abroad and wish to know what they may expect to see. The regional arrangement and the outcrop maps make reference easy. The principal regret of such users will be that there are not more books of this kind for other parts of the geological succession. D. T. DONOVAN

SEISMICITY OF THE EARTH and associated phenomena. By B. GUTENBERG and C. F. RICHTER. *Princeton University Press; London: Geoffrey Cumberlege*, 2nd edition 1954. 11×8 *inches;* 310 *pages; maps and profiles.* 80*s*

The second edition of this well-known book from the Seismological Laboratory,

California Institute of Technology, follows five years from the first. The pagination of the first edition has been kept with only minor alterations up to page 104. Thereafter a further discussion is given in consequence of the new seismological data which have accrued since 1949, and the 149 pages of tables of shocks have now expanded to 171. The great shock of 15 August 1950, near the tri-junction of India, China and Burma, is listed with a magnitude of 8·6, which is the highest in any land area since accurate instrumental records were first compiled in 1904. Each major seismic region is illustrated by a map in which shallow-focus (less than 70 kilometres), intermediate (70–300 kilometres) and deep-focus shocks are divided into four classes of magnitude. A profile across Hokkaido towards Manchuria shows the distribution of hypocentres from shallow-focus shocks below the 7-kilometre Pacific trench down an inclined zone of 35° to 500 kilometres in depth under Gore Sikhote Alin. The distribution of foci along this zone is so localized that it is safe to assume with Hess and Benioff that the whole Kurile–Japan–Ryu Kyu region is bounded by major marginal faults descending deep into the asthenosphere. Lake's rule clearly has some bearing on the angular disposition of the marginal faults. On a wider scale, Tuzo Wilson has demonstrated the fall of the mountain-arc centres into two great circles. It is of interest that the Himalayan arc, although characterized by major thrust dislocations against the foredeep of Siwalik and Gangetic sediments, does not exhibit shocks of intermediate focus, and presumably the bounding thrusts have a different behaviour at depth to those of the Japanese area. The cluster of intermediate foci in the Hindu Kush has no apparent orientation, and this is possibly connected with the complex knot of linked chains which exist in the Tadshik–Badakhshan area.

This book is of great value not only to seismologists, interested in the recording and classification of earthquakes, but to all who are concerned with the configuration of stable and unstable zones. The data are of importance, for example, in seismic countries such as India and Pakistan, where major multi-purpose projects are under construction and are involved in the problem of earthquake hazard. Just fifty-two years ago in 1904, when the first instrumental data of the present volume attained enough precision to have geographical value, the Geological Survey of India published a memoir by Count Montessus de Ballore on seismicity in the former undivided India. That memoir had to depend on historical records and undue weight was naturally given to centres of population such as Delhi, which acquired an apparent seismicity that had no relation to the actual, and then unknown, foci. The extent to which knowledge has now advanced as a consequence of seismographic studies may be seen in the book under review, for the delineation of seismic zones is now well developed, and results of great tectonic importance have been achieved, in the attainment of which Drs. Gutenberg and Richter have played a leading role. With the multiplication of seismograph stations, extended gravity observations, and a further knowledge of the ocean floor, there is no doubt that further refinements will quickly follow.

J. B. AUDEN

DAS GESICHT DER ERDE, mit einem A.B.C. Brockhaus Taschenbuch der physischen Geographie. Edited by ERNST NEEF. *Leipzig: Brockhaus Verlag*, 1956. 7½×5 *inches;* 980 *pages; illustrations, diagrams*

It is difficult to call to mind any English parallel to this handbook, for in content it is quite different from many similarly entitled studies. That is to say it is not a textbook of systematic physical geography, dealing with principles and processes, and illustrated by means of selected examples. Instead the first half consists of a description of the physical geography, *i.e.* physiography of the whole world, region by region, giving simply and clearly the important points of stratigraphy, structure and surface form (with occasional references to industry and urban centres). The climate and vegetational aspects, though partially considered under these regional headings, are dealt with more generally in the short introductory sections of the book. It is perhaps to be expected that the regions vary greatly in size, and in the treatment they

are afforded. Europe is dealt with in the greatest detail, and, in Europe, Mitteleuropa, *e.g.* the Rhine Massif has a more extended description than England. Even so, for most areas there is more detail of the physical "background" than is forthcoming from many a regional text-book. This section of the book is completed by an account of the oceans, with references to both form and water movements. The text is well illustrated with neatly drawn inset maps, though the photographic illustrations are badly placed.

The second half is a dictionary of terms used in physical geography, including those used in geomorphology, biogeography and meteorology. Here again there are numerous diagrams in the text. Whereas the first half is a most useful addendum to regional studies, this second half would be of great assistance to anyone reading German periodicals in an attempt to keep abreast of research. With 980 pages, a poacher's pocket would be needed before this could truly be considered a pocket book!

E. M. YATES

EQUATORIAL WEATHER. With special reference to Southeast Asia. By J. E. M. WATTS. *London: University Press, Ltd.*, 1955. 8½ × 5½ *inches; 224 pages; charts, diagrams and plates.* 25*s*

This is a clear exposition of equatorial weather processes mainly in southeast Asia and western Indonesia, with no more mathematics than is necessarily involved in the relation between the surface and upper air circulation. It is explained that air-mass analysis, distinguishing fronts separating polar, tropical, continental and oceanic air so important in temperate latitudes, has no application along the equator where neighbouring air currents differ little in temperature and humidity. There it has to give place to air-stream analysis which is much more difficult but equally important in forecasting. It is often difficult to identify different air currents having much the same physical condition, but convergence between them involving uplift of air is a potent source of clouds and rain in equatorial regions. Hence the author proposes that the familiar term "inter-tropical front" should be discarded in favour of "inter-tropical convergence" where the equatorial rains develop between the Trade winds. The convergence line, however, is greatly distorted from day to day in the Doldrum belt and in two regions, the Central Indian Ocean and Eastern Pacific Ocean, is interrupted by the intrusion of "Equatorial Westerlies" so that there are two boundaries instead of one. In Indonesia the newly discovered equatorial westerly winds further complicate the circulation pattern produced by monsoons and local factors.

New knowledge of this kind will, of course, eventually have to be compressed into the text-books of geography in a form of words carefully selected to preserve essential accuracy without disturbing the older conceptions more than is necessary.

In comparing on p. 65 the high intensity of rainfall at stations in Malaya with that in most temperate countries the author instances Ben Nevis as never having recorded quite as much as 8 inches in twenty-four hours. But this amount has been exceeded at ordinary lowland stations in England, notably near Weymouth where 11 inches fell during a thunderstorm on 18 July 1955. In France, moreover, there are records of over 20 inches in twenty-four hours.

The plates consist of excellent cloud photographs.

L. C. W. BONACINA

PROCEEDINGS OF THE SPELAEOLOGICAL SOCIETY, 1955–56. Vol. 7, No. 3. *University of Bristol*, 1956. 9½ × 6 *inches; 189 pages; illustrations and folding map.* 10*s*

The members of the University of Bristol Spelaeological Society have been working in north-west Clare for the past few years and some significant results of their work are given in their *Proceedings*. The most important paper is that by C. D. Ollier and Professor Tratman on "The geomorphology of the caves of north-west Clare, Ireland" which is a distinct contribution to the study of the origin of the British caves. The paper deals in particular with those caves which are situated close to the Namurian

Shale-Carboniferous Limestone boundary and which are still in an active stage of development. The factors involved in the formation of the caves (joints and veins, bedding planes, shale or chert banks and base-level) are discussed. The shape of the caves in this area indicate for the most part a formation in two stages; the authors conclude that these two stages are "the normal sequence of events of a simple progressive process" and that it is not necessary to invoke changes either in climate or in base-level to account for the cave development. The caves are regarded as being formed predominantly by solution caused by free-flowing (vadose) streams, and not by corrasion as is sometimes assumed; further, phreatic action plays only a small part in the cave formation. In the main, the caves are occupied by the streams which made them and show a close relationship to the surface relief. These facts together with the juvenile forms of the passages suggest that the caves are of post-glacial origin. This conclusion is supported by the association of the caves with small dry valleys unmodified by ice action, and containing no glacial drift. Whether this conclusion is correct or not, it is clear that this paper marks a step forward in the study of caves in this country and opens up several problems concerned with the rates of solution of limestone, especially under temperate and peri-glacial conditions.

The issue also contains detailed descriptions and surveys of certain caves in north-west Clare, notably that of the "Doolin cave system," by D. A. S. Robertson and others; the Society has done a fine piece of work in producing a complete survey of the Doolin cave, which contains 3·75 miles of passages. These descriptions and the paper by C. D. Ollier and Professor Tratman are illustrated by photographs and clear diagrams and there is a folding map to show the location of the caves in north-west Clare. The *Proceedings* includes, in addition, short papers of interest to the archaeologist and the Pleistocene stratigrapher, the most important of which is on "The Marine Pleistocene deposits in the Vale of Gordano," by A. M. ApSimon and D. T. Donovan.

M. M. SWEETING

POLITICAL GEOGRAPHY AND THE WORLD MAP. By Y. M. GOBLET. *London: George Philip, 1955. 8½ × 5⅜ inches; xviii + 292 pages; maps and plates. 30s*

In 'The twilight of treaties' (1936) Dr. Goblet demonstrated effectively the value of geographical analysis to the understanding of current international affairs. In this larger work he attempted, in the light of many years of teaching and study, to present an objective and systematic political geography of the modern world. While 'Political geography and the world map' does not achieve what it set out to do and invites criticism on many grounds, it provides a useful text for the student who is already well grounded in political geography and is prepared seriously to consider and evaluate Dr. Goblet's concepts, principles, classifications and judgments.

The scope and content of the book can be briefly indicated by reference to its seven parts. The first deals with the nature and method of political geography and the second with the concepts "territory" and "population." Part 3 examines "state" and "nation" and their relationship, and Part 4 routes and frontiers. In Part 5 Dr. Goblet makes a case for a classification of States into "intensive, "extensive" and "mixed" types and discusses their evolution and dissolution. Parts 6 and 7 are devoted respectively to colonies and successor states and to regions of contemporary geopolitical interest. Part 8 entitled "Conclusion, ' merely glances at the political patterns of the present world, noting the change in Europe's role in international affairs and the creation of "great political regions" such as N.A.T.O.

Dr. Goblet's book is concerned mainly with the external relationships of states, especially in terms of their political power. It has surprising omissions on matters relevant to the internal aspect of states; for example, their federal or unitary organization, their capital cities and their administrative patterns. Dr. Goblet does not achieve his hoped-for objectivity. We are continually conscious that it is a Frenchman's view of the world we are offered: witness the discussion of "intensive" and "extensive" states (pp. 186–8). It is a pity that the state is equated to an organism

(p. 3), for that is seriously misleading. It is difficult to share the author's interest in that will-o'-the-wisp, a state's "optimum territory." Political geography as a systematic branch of the main subject has a long way yet to go. 'Political geography and the world map' underlines this fact and it should stimulate further interest and thought.

W. G. EAST

DIE NATÜRLICHE LANDSCHAFT UND IHRE RÄUMLICHE GLIEDERUNG. Eine methodische Untersuchung am Beispiel der Mittel- und Niederrheinland. By K. PAFFEN. Forschungen zur Deutschen Landeskunde. Band 68. *Remagen: Verlag des Bundesanatalt für Landeskunde*, 1953

DIE NATURBEDINGTEN LANDSCHAFTEN DER DEUTSCHEN DEMOKRATISCHEN REPUBLIK. By J. H. SCHULTZE and others. Petermanns geogr. Mitt. Erg.-Heft. Nr. 257. *Gotha: V. E. B. Geographisch-Kartographische Anstalt*, 1955

HANDBUCH DER NATURRÄUMLICHEN GLIEDERUNG DEUTSCHLANDS. 1 and 2 Lieferung. By E. MEYNEN and J. SCHMITHUSEN. *Remagen: Verlag des Bundesanstalt fur Landeskunde*, 1954, 1955. 10×7 *inches;* 258 *pages.* 58*s*

These books belong to a family of enquiries into the best methods of making a useful regional division of Germany. Though for some years there has existed a detailed map of the regions of Germany made by consulting a large number of geographical experts, these three works still belong to a preparatory generation of analytical and summary works, for up to now the dissertations and works of regional description that must have been expected have not appeared.

Paffen has produced a beautifully printed map of regional divisions for the lower Rhine country which by itself is a superlative example of cartography. This has been used in an earlier form in 'Geschichtlicher Handatlas der Deutschen Länder am Rhein. Mittel- und Niederrhein (Köln und Lörrach),' 1950, a volume that can claim to be the most helpful local historical atlas available. His discussion of the methods of regional division, while rather complex in structure, are precise and practical. He solves the problem of selecting a minimal geographical unit by using a synthetic one made up of various local elements blended in characteristic proportions. A family of such smallest units can be recognized where the constituent local elements are only slightly different in emphasis. A new family can be recognized where new local elements appear and change the general balance of the constituents. Thus a very subtle system of regional differences can be discovered allowing for every significant nuance. Paffen does not greatly recommend a hierarchy of regions building up to major regions. There seems no real reason why, in a small area, one should lay emphasis upon regions of increasing generality. Paffen's work is essentially on a local scale and hence relies upon a complete mastery of pedology, hydrology and the methods of plant ecology and micro-geomorphology. The most successful element in the work of present-day geographers in Germany, and especially those from Bonn, is their balanced mastery of wide fields of natural history.

Schultze's work on Eastern Germany gathers together the deliberations of a syndicate. His general considerations about the nature of a region converge with those of Paffen and his discussion of how lines can be drawn to divide regions, and the examples he gives, are very useful. It is possible to compare his map of Eastern German divisions with that of the wartime committees. In fact more can be learned by discussing the boundaries drawn by a number of rival regional analysts about the essential character of an area than a perfect set of dividing lines could provide. Divisions of this type are made, one supposes, less for their own sake than to get a better idea of the region described. Schultze provides descriptions, in summary form, of the areas into which he proposes to divide the country, but they are too brief to be of much value except to indicate the criteria for separation.

The third work consists of a series of tightly packed descriptions by a group of expert writers using the divisions of Germany made during the war. It also runs

parallel with the publication of various maps on the scale of 1 : 200,000 with detailed local regional divisions marked upon them, and summary descriptions on the reverse side. The descriptions, though not homogeneous in treatment, are, where they are most successful, masterly and compact summaries of the various elements of geomorphology, climate, vegetation, hydrology and settlement. Each writer follows his own bent within a wider system. It does not intend to provide a new geography of Germany and it ignores economic and town geography. This neglect need not be permanent as census and production statistics are now collected so that they can be evaluated within the framework of these regional divisions and so be of use to national and local administrations. Will a parallel enterprise of describing each *Landkreise*, administrative units about the size of our smaller counties, provide a more useful form of regional description? Since the war no first-rate regional geography of Germany or Central Europe has been written. These analytical studies in regional division should provide a controlling framework for a more elegant description in the future.

D. J. DAVIS

INTRODUCTORY ECONOMIC GEOGRAPHY. By L. E. KLIMM, O. P. STARKEY, J. A. RUSSELL and V. H. ENGLISH. Edited by J. Russell Whitaker. *New York: Harcourt Brace*, 1956. $9\frac{1}{2} \times 7\frac{1}{2}$ *inches;* 730 *pages; maps and photographs*

CHISHOLM'S HANDBOOK OF COMMERCIAL GEOGRAPHY. Edited by L. D. STAMP and S. C. GILMOUR. 15th edition. *London: Longmans*, 1956. $8\frac{1}{2} \times 5\frac{1}{2}$ *inches;* 915 *pages.* 70*s*

WORLD ECONOMIC GEOGRAPHY. By EARL B. SHAW. *New York: John Wiley; London: Chapman and Hall*, 1956. 9×6 *inches;* 582 *pages; maps and photographs.* 52*s*

A mathematical friend once told me the fantastically large number of different ways in which a pack of cards may be dealt. One fears that the number of ways in which topics of so-called economic geography are being shuffled, redealt and published as introductions to economic geography may soon reach an even greater magnitude. 'Introductory economic geography' is yet another of these compendiums of American origin, with a strong American bias, and is neither better nor worse than most of its fellows. This third edition differs from its ancestors in that the introductory chapters on basic concepts and maps have been abridged. Tactically this is an error—either expansion or elimination would have been preferred. It is difficult to envisage the area of use in which this book could be employed in this country. Apart from its strong American flavour, statements such as "The grazing industries utilize vast areas of grass, which man cannot eat" (p. 247) raise the question of how "introductory" can one get?, whilst earlier in the book terms such as "Sequent occupance" (p. 149) are certainly the sort of expertise from which beginners, if not everyone, ought to be shielded.

'Chisholm's handbook of commercial geography,' now in its 15th edition, reminds one of certain friends of one's youth—the former boon companion has surely put on weight, dresses more garishly, and has not on the whole worn very well! Seriously, has this once useful compendium outlived its purpose? The casual enquirer may still find Chisholm's serviceable for occasional reference, but for the student of geography something more stimulating is required. This handbook is neither source nor interpretation. To its credit stands the fact that through its title we are reminded that there is a distinction between "commercial" and "economic" geography. American compilers obviously require such a reminder.

Shaw's book is to be commended in that here, at least, is an attempt to meet Professor Wooldridge's cry for the formulation of "an economic geography worthy of the name," and is especially refreshing in that it is much more concerned with methodology than with attempting a comprehensive factual summary of the world's economic activities. There is nothing profound about the book, nor does it pretend to do more than to illustrate the main approaches to economic geography, but this it

does well. The worst part of the book is at the very beginning—to the self-posed question "What is economic geography?" we get "The complete answer involves where can, where are, why are, when are, and how are." "What is" has to be deduced from what Shaw subsequently suggests economic geographers ought to do. The remainder of the introductory section considers the four main approaches to economic geography—"regional," "activity," "commodity" and "principles"—each supported with well chosen examples. It is this introductory section which gives the book its main distinction and which makes it an excellent text for either sixth form or first year university students starting a course in economic geography. A. C. WOODCOCK

LA CAMPAGNE. By PIERRE GEORGE. *Paris: Presses Universitaires de la France*, 1956. 10×6½ *inches;* 389 *pages; maps and photographs.* 1600 *frs.*

Students will find in this book a useful, if superficial and often elementary, treatment of several aspects of a very large subject. The first of its five parts examines on a world scale the agricultural basis of rural societies and the varied expressions of relations between agricultural economies and the earth. It includes a good summary of different patterns of rural settlement, illustrated by photographs and well-chosen extracts from topographic maps. There follow sections that deal with the major types of peasant economy that are represented respectively in the inter-tropical and sub-tropical zones and in western Europe. An unevenness of treatment which mars the book as a whole is especially apparent here. Whereas over forty pages are devoted to a description of the diversity of the French rural economy and another sixteen pages to a chapter on that of Italy, the rest of north-west Europe is summarily dealt with in less than twenty pages. The treatment of the agricultural economy of Britain that is included is so scant as to be of little value; and in a three-page bibliography at the end of this part the only work in English that is cited is the well-known general text-book on the British Isles by Professors Stamp and Beaver.

The fourth part, "Campagnes spéculatives, campagnes sans paysans," which deals with large-scale commercial agriculture as exemplified by North America and the plantations of the Hot Belt is likewise very thin and fragmentary, and shows only a slight and haphazard acquaintance with relevant literature in English. A final part deals with the rural economies of the Communist countries, with special reference to their modern transformation. Here China is dealt with in seven pages, after a fourteen-page chapter on the Soviet Union and sixteen pages devoted to the Peoples' Republics of east-central Europe.

Viewed as a whole this work is neither a scholarly nor a well-balanced, much less an exhaustive analysis of the subject it sets out to examine. It amounts to a compendious assemblage of the literature with which the author is familiar, though not all the material drawn upon has been well digested and developed into a closely reasoned analysis. The most obvious and serious defect, however, is the absence of attention to great masses of the admittedly vast corpus of literature on the subject. Much of this, especially in English and German, appears to lie outside the author's ken. Within the serious limits noted, the book conveniently presents a considerable body of general information, with illustrative examples about varied agricultural economies and their manifestations in the diversity of the countryside. A. E. SMAILES

MAN'S ROLE IN CHANGING THE FACE OF THE EARTH. An International Symposium under the co-chairmanship of Carl O. Sauer, Marston Bates and Lewis Mumford. Edited by William L. Thomas, Jr. *Chicago: University of Chicago Press (on behalf of the Wenner-Gren Foundation for Anthropological Research, and the National Science Foundation)*, 1956. 9½×6½ *inches;* xxxviii+1194 *pages; illustrations.* 94*s*

Planning of this symposium, 'Man's role in changing the face of the earth,' began in 1952, and was extremely well done; the Wenner-Gren Foundation acting as the hosts for a first-rate party of scholars. Papers were written and circulated in advance,

which about fifty of the seventy scholars invited to the meeting had been asked to prepare. Wisely, the subjects were in general chosen for, and not by, the writers, bearing in mind what was known of their personal interests as well as their specialist knowledge. A most refreshing result of this method has been that various people successfully wrote under a title which took them beyond their particular specialist interests into fields which they might otherwise have been too modest to enter.

The papers were divided into three Parts, "Retrospect," "Process" and "Prospect," and the time-table of the symposium was designed for free discussion in the same three parts. There was a final summing up by Carl O. Sauer (Retrospect), Marston Bates (Process), and Lewis Mumford (Prospect). Everything possible was done, and successfully done, to have the participants regard themselves as "amateurs," as Professor Sauer put it, and not "pros." The finest feature perhaps of the published book of papers is that it manages to convey much of the exhilaration that the participants themselves obviously felt in following many new and rewarding trains of thought.

To give some idea of the background of the participants, fourteen of whom were from outside the United States, "about 40 per cent. were in the field of earth science, 28 per cent. in the biological sciences, 12 per cent. in the social sciences and the humanities, and 20 per cent. in applied fields (administration, city planning, etc.)." The United Kingdom members were H. C. Darby, E. Estyn Evans, Michael Graham, A. Leslie Banks, F. Fraser Darling, Sir Charles Darwin, and E. A. Gutkind. Geographers were ably represented, not only by the two first mentioned from this country, but by a dozen from the United States, and three from other countries. But to give these figures is to draw attention away from the fact that almost every page in this 1200-page book is good reading for all geographers.

This book is perhaps the best guide yet to what conservation and regional planning really involve. In such a vast field, certain aspects inevitably receive little treatment even in a symposium of this kind. But the symposium was an outstanding corrective to particularist thought and action, and it may even be said to be a merit in the book that some important matters, such as bird protection, which currently are disproportionately weighted, should receive scant attention. F. H. W. GREEN

CARTOGRAPHY

THE FABER ATLAS. Edited by D. J. SINCLAIR with a preface by Professor L. Dudley Stamp. *Oxford: Geo Publishing*, 1956. 12×8½ *inches;* 146 *plates.* 32*s* 6*d*

To say that the Faber Atlas has been produced by a leading cartographic enterprise, Ed. Hölzel of Vienna, who also produced the Lautensach 'Atlas zur Erdkunde' in 1954, is not to imply that the Faber Atlas is a mere reprint with English sub-titles. A comparison of the two reveals that a considerable amount of work has been put into the Faber Atlas both in the selection and design of new plates for the British market and the combing-over of retained plates to remove the many Germanicisms of the original. Essentially the Atlas is a teaching atlas, and its arrangements and contents seem in many respects to be an upper school geography text-book come to cartographic life. Thus the relief representation has a boldness of conviction which some may find aggressive, and most of the maps contain a sprinkling of geographical descriptive terms which are alien to the countries concerned but useful for teaching.

Most areas are covered in reasonable detail considering the size of the atlas. The plates are on the whole very successful aids to regional treatments. The British Isles are well covered at 1 : 1,250,000 with more detailed consideration of important areas at 1 : 200,000. Typical local forms are expressively developed at even larger scales. Land use maps are a feature both at large and small scales. In this respect surely an apology is impending when Northern Ireland is shown as having no land use survey! A useful collection of climatic, economic and other distribution maps are included and

there is an index to names. One major aspect of geography is left to the teachers to put over unaided. The reviewer feels that the total omission of roads from the general plates is the weakest feature of the atlas.

The rather enthusiastic preface seems out of place in that although eminently quotable it contributes little to the usefulness of the atlas. Of the features it mentions, metric representative fractions, good relief and adequate detail are no longer novelties in other countries. Indonesia and other small nations also put air photos and regional maps in their school atlases; the emphasis on their inclusion in this particular production rather points to the extreme backwardness of British school atlases, to which group the Faber Atlas is a welcome, if by international standards laggard, addition. An introduction giving some validation of the statistical and economic maps, and an explanation of the form of place-names, and perhaps the inclusion of the original Lautensach plate illustrating the projections used, would have given added value to this well conceived and excellently drawn and printed atlas. IAN MUMFORD

HISTORY OF EXPLORATION

Volume three of the new series 'Histoire universelle des explorations,' by P. J. Charliat, is entitled LE TEMPS DES GRANDS VOILIERS (*Paris: Nouvelle Librairie de France*, 1955). This well-written and instructive book covers approximately the two centuries from A.D. 1600 to 1800, the era of the great voyages under sail. M. Charliat is successful in selecting and evaluating the various influences that contributed to this great movement which resulted in the exploration of most of the coasts of the world and, it should not be overlooked, a considerable part of the interior also. It is to him a period of careful calculation, by the bourgeois directors of the trading companies of Britain and Holland, of economy of outlay, of competition and consolidation. It is also a period of great missionary activity, symbolized by the foundation of the "Pro Fide Propaganda" College, and a time of scientific and intellectual awakening, when the naturalists and archaeologists begin to re-discover the world around them. This spirit of inquiry continued to grow throughout the era, widening its field of activity, and at its close is personified by men like James Cook and Alexander von Humboldt. The space at M. Charliat's disposal allows him to deal in some detail with numerous voyages and journeys, and his book is well illustrated by reproductions of contemporary prints and maps. It is pleasant to find in it a tribute to Edward Heawood's history of discovery in the seventeenth and eighteenth centuries.

La Vérendrye, briefly referred to by M. Charliat, is comprehensively and authoritatively treated by Nellis M. Crouse (LA VÉRENDRYE. *Cornell University Press; Geoffrey Cumberlage, Oxford U.P.* 1956, 32*s*). Soldier, official and fur trader in Canada, he was drawn onwards by tales of a great "western sea." He never found this, for there is little doubt the tales related to the Gulf of Mexico. He himself reached the Mandan country, south of the Assiniboine river, and one of his sons was probably the first white man to see the Rocky Mountains. Dr. Crouse discusses the debatable points in La Vérendrye's routes and supplies bibliographical references to the sources.

BLACK GOWN AND RED SKINS, not a very happy title, also deals with the opening-up of North America (*Longmans*, 1956. 25*s*). For it, Miss Edna Kenton has selected and reduced in length the more striking parts of the Jesuit 'Relations,' published in full by R. G. Thwaites. Here, translated from the original accounts, generally set down shortly after the events, are the missionaries' experiences with the Indians, and the ordeals which many of them underwent, full of incident, details of Indian ways of life, and discussions of their religious beliefs. Within this period, the outstanding feat of exploration by the Jesuits was the descent of the Mississippi river by Fathers Joliot and Marquette. G. R. CRONE

OCEAN EXPLORATION

WINDOW IN THE SEA (*Gollancz*, 1956, 18*s*) is a most readable account by Ralph Nading Hill of the planning, building and stocking of the Marine Oceanarium in Florida, the bringing of the sea ashore for the delight of the land dweller. The other two books reviewed here are concerned with the submarine activities of frogmen. DAHLAK (*Nicholas Kaye*, 1956, 25*s*) is a lively narrative by G. Roghi and F. Baschieri (translated by Priscilla Hastings) of the Italian National Underwater Expedition to the Red Sea, which was led by Dr. Bruno Vailati; members of the Society will recall his interesting talk to them. MOANA, meaning 'vastness of the waters' (*Elek*, 1956, 21*s*) is also a narrative, but the author Bernard Gorsky and his companion were concerned with adventure rather than with natural history.

The oceanarium in Florida is now a flourishing concern, but Mr. Hill tells us of the many problems that had to be solved before it became an actuality. Construction began in 1937 and by June 1938 the Marine Studios were ready for the public. During this time suitable inhabitants had to be caught and a way found of anaesthetizing sharks after capture. Difficulties were experienced in the keeping of such fast-swimming fishes as mackerel, marlin and sailfish. When war broke out some of the scientists were given the essential task of finding a shark repellant for use with the services. The account of how they arrived at copper acetate makes very interesting reading. After the war the oceanarium was restocked with many kinds of fishes and there are interesting observations of their behaviour in captivity. But the story of the bottle-nosed dolphins and Herman, the pilot-whale, is the most absorbing part of this book. People whose only acquaintance with dolphins is an occasional sight of them at sea, will surely be amazed at the extent of their play and intelligence. Such interesting facts, and many others, appear in this well-written book, which is illustrated by a series of excellent photographs.

'Dahlak' is the name of the island off Massawa where the Italian Expedition did their underwater work. Roghi has written the narrative while Baschieri provides an appendix dealing with general observations on the flora and fauna. The book is illustrated by numerous photographs but those taken underwater are not good. There are some very interesting natural history observations: the dance of the manta-rays giving birth to their young; the attachment of pilot fishes for frogmen; the gathering of hermit-crabs around sea-ospreys' nests, and the jackdaw-like habits of ocypodid crabs.

'Moana' contains the underwater adventures of Bernard Gorsky and his colleagues in the tropical Atlantic and Pacific oceans. It is well written and there are amusing accounts of contacts with people as well as with fish. But too often the reaction on seeing a sizeable fish is to pull the trigger. Modern submarine man with a lethal weapon soon becomes primitive man, the hunter.

N. B. MARSHALL

THE SOCIETY'S NEWS

NEW YEAR HONOURS LIST

Mr. J. M. Wordie, C.B.E., President of the Society from 1951 to 1954, recipient of the Back Grant in 1920 and of the Founder's Medal in 1933, and Fellow of the Society since 1921, becomes a Knight Bachelor in the New Year Honours, for "services to Polar exploration." Colonel R. Meinertzhagen, the well-known ornithologist and traveller in North Africa, who has been a Fellow of the Society since 1903, becomes a Commander of the British Empire.

DONATION TO THE SOCIETY

In November 1956, the Society received a very generous donation of £1000 towards its funds from Mrs. Florence Kerr Wilson, of Karen Chase, P.O. Ngong, Kenya Colony. Mrs. Kerr Wilson has been a Fellow of the Society since 1921. The President and Council greatly appreciate Mrs. Wilson's generosity and her thought for the Society's welfare in these very difficult times.

RESEARCH STUDENTSHIP IN GEOGRAPHY

The Council of the Society announces the establishment of a research studentship in the coastal geography of Roman Britain, centred initially on the Thames Estuary. Applications are invited from graduates with qualifications in physical geography, and the tenure of the studentship will be one year with possible extension to two; the stipend will be £450 a year plus travelling expenses, and the starting date 1 July 1957. Applications, with names of two referees, should be sent to the Director and Secretary of the Society, 1, Kensington Gore, London, S.W.7, by early April.

ANTARCTIC EXPEDITIONS

Shortly before the sailing of M.V. *Magga Dan*, the Trans-Antarctic expedition's ship, the President on behalf of the Council sent Dr. Fuchs "the most cordial good wishes for the success and prosperity of your great venture and for the happiness and well-being of all concerned." Dr. Fuchs replied from on board the *Magga Dan*, and assured the Council that "We do not forget that it was the Society which made the first grant of money to the expedition, and we shall certainly do our best to justify all the assistance we have received from the Society and from so many other sources."

On November 16 the President sent a telegram of congratulation to Admiral R. Byrd, U.S. Antarctic Program, on the fine achievement of Admiral Dufek and his men in landing the first aircraft at the Geographical South Pole, where the United States, in the course of "Operation Deepfreeze II," have established a station by air in preparation for the International Geophysical Year.

POLAND AND THE SOCIETY'S 125TH ANNIVERSARY

The Polish quarterly periodical *Wiadomosci Geograficzne* (published by the Geographical Institute of the Polish Academy of Sciences, Warsaw, part 3, 1956) contained a note on the Society's 125th anniversary, from which the following is quoted:

"In 1955, the Royal Geographical Society celebrated the 125th anniversary of its existence. On the occasion of the annual assembly, the President of the Society, General Sir James Marshall-Cornwall, gave an address. He gave a short account of the Society's history, and of how it had played a famous part in the discovery of Africa—Livingstone, Speke, Burton, Grant, Baker and others travelled under its aegis, and so, up to a point, did Stanley. Several of the Society's expeditions explored Arabia, Central Asia, Australia and South America, and the Polar regions, and the present-day map of the world owes much to their discoveries.

"The Society also deserves praise for the results it has achieved in the field of

teaching geography. The names of Freshfield, Galton, Scott Keltie and Halford Mackinder are well known . . . and in 1899 the Society helped in the founding of the first chair of geography in the British Isles, at Oxford. . . . The President mentioned the question of admitting ladies as Fellows, a subject discussed but dismissed in 1847. It arose again in 1892, only to be rejected again, and one of the Fellows, Nathaniel Curzon, wrote to *The Times* on the inability of women to contribute in any way to geographical knowledge. Twenty years later this same Curzon (later to be responsible for the 'Curzon Line'), President of the Society, put the matter to the vote, and 2000 voted for and 674 against were counted. Today out of 6500 Fellows, 20 per cent. are women. . . ."

SPECIAL MEETINGS AND FILMS DURING 1956

Meetings were well attended throughout 1956, and of particular interest in the 1955–6 session were Sir Mortimer Wheeler's lecture on "East Africa's ancient past" (Mrs. Will Gordon lecture for 1956), Miss Freya Stark's on "Some minor battlefields of Alexander,' and Dr. Vivian Fuchs' account of the Trans-Antarctic Reconnaissance of 1954–5. A joint meeting was held with the Alpine Club early in the 1956–7 session at which Albert Eggler, F. Luschinger and Captain H. von Gunten described the Swiss ascent of Everest and Lhotse. On January 1 a joint meeting was held, with the Society's President in the Chair, of the Geographical Association, the Institute of British Geographers and the Royal Geographical Society. This was addressed by the President of the Geographical Association, the Rt. Hon. the Lord Nathan, P.C., T.D., D.L. (who is also a vice-President of this Society), on "Aviation and geography."

Outstanding among films shown during 1956 were the unique contemporary record of Shackleton's Imperial Trans-Antarctic Expedition "South," and Duncan Carse's film of the work of the South Georgia Survey, "Gateway to the Antarctic."

As usual, the hall was filled to capacity for the children's Christmas lectures on December 31 and January 2. On the first date Kevin Walton, accompanied by his famous husky "Sister" and two rock-hopper penguins, and assisted by Bernard Stonehouse, spoke afternoon and evening on "Antarctic adventure today"; part of the film of the 1954–5 Antarctic Reconnaissance was shown. On January 2, David Attenborough described—also afternoon and evening—his "Search for a 'dragon' in Indonesia," and showed a film of the expedition to collect and photograph rare animals in Java, Bali and the unique "dragon" island of Komodo.

An exhibition of Antarctic equipment, relics and photographs was shown, in cooperation with the Scott Polar Research Expedition at Cambridge, from December 31 to January 14, and was visited by well over 4000 people, including several parties of schoolchildren. Earlier in the year, Professor N. E. Odell lent the Society, for show in the ambulatory, his impressive collection of photographs of the New Zealand Alps, taken by the Royal New Zealand Air Force.

EXPEDITIONS IN THE FIELD DURING 1956

Reports have been submitted to the Research Committee from expeditions to which financial grants were announced in the *Journal* for June 1956. Unless otherwise stated the expeditions worked during the Long Vacation of 1956, and the full reports may be seen in the Society's library.

1. OXFORD EXPEDITION TO 'IRAQI KURDISTAN

Led by John Wilkinson, arrived in Kurdistan via Beirut, Tripoli, Kirkuk and Berbil, and established a base camp at Gallala from which they walked some 500 miles in north-east 'Iraq.

2. OXFORD AND CAMBRIDGE EXPEDITION TO NORTH 'IRAQ, 1956

Led by Simon Enthoven (Cambridge), this party spent some five weeks in the Mosul region, at Hatra, at Amadia, and at Zakho.

3. CAMBRIDGE ECOLOGICAL EXPEDITION TO MACEDONIA, 1956

This party, led by P. J. Grubb, spent a month making an ecological study of the Prokletije, or north Albanian Alps, where they cross into southernmost Serbia.

4. RATANG–PARBATI HIMALAYAN EXPEDITION, 1956

This expedition, led by P. J. Holmes, collected ammonite fossils from the Spiti Shales, and mapped in the area.

5. GOUGH ISLAND SCIENTIFIC SURVEY

J. B. Heaney's and M. W. Holdgate's account of the Gough Island Survey is printed in full on pp. 20–32 of this *Journal*, together with the map.

6. BRITISH ANDEAN EXPEDITION

This expedition, led by J. S. Jewell, had as its goal the exploration of a little-known part of southern Peru, the Cordillera Vilcanota, south-east of the old Inca capital of Cusco, which borders on the Amazon basin. They left England in April and returned in August.

7. NORTH SWEDEN RESEARCH GROUP (UNIVERSITY COLLEGE, LONDON), 1956

The group, led by R. P. Kirby and D. B. Owen, included research workers in geology, botany and geomorphology. The area chosen for field work was in the extreme north of Sweden, between the districts of Katterjaure and Sjangeli.

8. CAMBRIDGE NORTH PERSIAN EXPEDITION, 1956

The expedition under W. J. Norton spent three weeks in the area of the Alam Kuh massif and Kalardasht valley. A second area visited was west of Mount Demavend.

9. ANGLO-NORWEGIAN FROZEN GROUND RESEARCH EXPEDITION, 1956

This summer's expedition, led by P. J. Williams, was divided into three parts: a detailed instrumental investigation was made of the mechanics of solifluction occurring beneath a late snow patch on a steep slope in Dovrefjell; annual reinvestigation of certain solifluction features was continued; and a general survey was made of solifluction features in Rondane.

10. DURHAM UNIVERSITY EXPEDITION TO NORWAY, 1956

This expedition, led by W. A. Elders, visited the northern part of the Lyngen Peninsula, and studies were made in glaciology, geomorphology and geology.

11. DURHAM UNIVERSITY EXPEDITION TO YUGOSLAVIA, 1956

A party under the leadership of B. G. Light was the first to visit Yugoslavia from Durham since the founding of the Exploration Society. It had as its object a geographical, geological and biological study of the Krbvasko *polje* which lies within the Republic of Croatia.

The Durham Exploration Society has also submitted reports on expeditions to Switzerland, Eire and the Cairngorms, and have sent in important information about dehydrated foods used on the Society's expeditions.

12. SOUTH GEORGIA SURVEY, 1955–6

Expedition reports have been received of the progress of the Survey to date, from Duncan Carse, who is on his way to do four months' further survey work.

13. OXFORD AND CAMBRIDGE FAR EASTERN EXPEDITION

This Expedition has returned to Europe after a year abroad, and their progress report, dated August 1956, describes the work of the two teams. The team under Tim Slessor carried out studies on mineral development in the Shan States and the other, led by Pat Murphy, completed the work begun last November on research into irrigation in West Pakistan.

THE RECORD

CONTRIBUTORS TO THIS ISSUE OF THE *JOURNAL*

Lieutenant-Commander M. J. N. Foster, R.N., was the United Kingdom observer on Operation Deepfreeze I, the United States Antarctic expedition which laid down the first bases for the International Geophysical Year. *L. P. Kirwan*, Director and Secretary of the Society, has done nine seasons of field work in Nubia; as assistant director of the Egyptian Government's Archaeological Survey and as director of the Oxford University archaeological expedition to the Sudan. *J. B. Heaney* worked with Duncan Carse on the South Georgia Survey (1951–2), and received (jointly with J. T. Hollin) the Watkins Award for 1956 for his work in South Georgia and on Gough Island; *M. W. Holdgate* is at present lecturer in zoology at Manchester University. *J. V. Harrison*, reader in structural geology at Oxford, carried out geological surveys in Peru in the course of six visits between 1939 and 1954. *F. G. Emmison* is county archivist of Essex, and editor of the Essex Record Office publications; *R. A. Skelton* is superintendent of the Map Room at the British Museum. *P. J. Williams*, Tennant Student of Cambridge, has been leader of Anglo-Norwegian field groups in the Norwegian mountains for the past three summers, and is at present carrying out research into solifluction in the Faculty of Natural Sciences, Oslo. *J. N. Jennings*, author of the R.G.S. Research Memoir "The origin of the Broads," is reader in geomorphology in the Department of Geography, Australian National University, Canberra. *A. J. Thomasson* worked for three years at the Soil Survey of England and Wales, and is at present seconded to Hunting Technical Services for soil survey work in 'Iraq; *C. D. Ollier*, after training at Rothamsted, is now on the staff of the Agricultural Department in Uganda.

UNIVERSITY NEWS

UNIVERSITY OF OXFORD

The last detailed note on the Oxford School of Geography appeared in the *Journal* in March 1954 (**120** (1954) 113–4). During the past few years the number of undergraduates reading geography has steadily increased, from 167 in 1952–3 to 233 in 1956–7. The latter figure includes 35 from St. Edmund Hall, which has now more than twice as many geographers as any other college and has its own geographical society, the Cosmographers. Keble (17), Jesus (15), St. Catherine's (15), University (11), Brasenose (10), Hertford (10), and Pembroke (10) are the other leading men's colleges in number of geographers, while St. Hugh's (12) has more than a third of the women reading geography.

R. W. Steel left Oxford in January 1957, to take up his appointment as John Rankin Professor of Geography in the University of Liverpool. His place as university lecturer in Geography has been taken by N. C. Pollock, a graduate of both St. Edmund Hall and Cape Town University, who has spent some years as head of the Department of Geography at Fort Hare University College in South Africa, and who will continue Mr. Steel's teaching on African geography. F. V. Emery of Jesus has also returned to Oxford as departmental demonstrator, after three years at University College, Swansea, and is now teaching the geographers of St. Peter's Hall. Miss M. M. Sweeting was elected into a Fellowship at St. Hugh's College in 1955, and C. Gordon Smith was elected into an official Fellowship at Keble College in December 1956. When Mr. Steel left he resigned the Fellowship at Jesus which he had only held for one year; but if that Fellowship is included, the number of college Fellowships held by university teachers of geography is now six. Twenty years ago only one college Fellowship was held by a geographer, the professor's official Fellowship

at Hertford. There has also been some improvement in the number of awards for geography. Hertford College have decided to offer a Macbride Scholarship in geography every year instead of every third year as hitherto. St. Catherine's Society has also agreed to offer an award in geography every year. St. Hilda's College has made an award in geography for two successive years. The number of research students has increased and the Professor now holds a seminar for these students only. J. B. Ooi, of St. Antony's, was awarded his D.Phil. for a thesis on "Geographical problems of rural development in tropical areas, with special reference to Malaya." He has now returned to Singapore to take up an appointment as lecturer in geography in the University of Malaya.

One recent change in the syllabus of the Honour School is of some interest. After prolonged discussion it has been decided to add the Middle East as one of the options in the list of regional papers as from 1958. Two university prizes, the Herbertson and the Beckit are now awarded every year for the two best geographical descriptions written by candidates in the Honour School. Every candidate is required to submit a "Geographical description" in not more than 15,000 words of a piece of country about 150 square miles in extent. An increasing number of these descriptions are concerned with areas outside the British Isles.

In March 1956 there was an Easter excursion to Britanny led by E. Paget, M. J. Webb and Miss E. Buxton, and the party received invaluable help in the field from Professor A. Guilcher of Nancy. In the summer of 1956 Dr. J. M. Houston attended the International Geographical Congress at Rio de Janeiro as the representative of the University of Oxford. In October Professor E. W. Gilbert visited Vienna to represent the School at the centenary celebrations of the Geographical Society of Vienna, and made useful contacts with geographers from Austria, Poland, Hungary and Yugo-Slavia.

During recent months the School has received many distinguished geographers as visitors including Professor Jules Blache, Rector of the Academy of Aix-en-Provence; Professor N. Moussly (Damascus); Commander P. K. Killinen (Helsinki); Professor Paul Marres (Montpellier); Dr. Albrecht Gruessner, head of the geographical service of the West German Foreign Ministry; and Professor M. Klimaszewski, Vice-rector of the University of Cracow. Professor Blache received the honorary degree of D.Litt. from the University of Oxford in June 1956 and the Public Orator compared his work with that of Posidonius. The university had not given an honorary degree to a geographer since 1948 when an honorary D.Sc. was conferred on Dr. Isaiah Bowman. During 1956 the Herbertson Society maintained its close relations with the R.G.S.; Mr. G. R. Crone addressed one of its meetings and Mr. L. P. Kirwan was the guest of honour at the Society's annual dinner.

The School has recently acquired additional accommodation in the form of a well-equipped map room which is used for classes and research. The Map Curator (Miss E. Buxton) has compiled a list of geological, climatic, economic, population and other non-topographical maps, published after 1940 and available in Oxford libraries. A copy of this list of special maps has been deposited in the R.G.S. The increase in the number of undergraduates reading geography would have been difficult to meet if the Map Room in the New Bodleian had not been available. It is fortunate that this room is only 300 yards from the School, and its tables for over thirty readers are always crowded in term; its walls are lined with text-books and periodicals. The Map Room in the New Bodleian, only opened in 1947, has already become one of the finest instruments of geographical research in this country. Its collection now includes over one million maps, and as the map cases adjoin some of the Library's famous collections of topographical books such as the Gough collection of early topographical books and subsequent additions, the Map Room is an invaluable asset to all geographical work in Oxford. One of the Library's greatest treasures, the fourteenth-century map of Great Britain bequeathed with the Gough Collection, will be reproduced in exact facsimile this year, a joint venture of the Library and the R.G.S.

Mr. E. J. S. Parsons, Map Curator of the New Bodleian, lectures annually on modern cartography to undergraduates from the School of Geography.

The controversy about Oxford roads has continued to drag on and there have been long debates on this subject in Congregation. Two geographers, J. N. L. Baker and C. Gordon Smith, spoke in one of these debates in the Sheldonian theatre, and the latter's lively but technical contribution, essentially geographical in character, received a good hearing from a crowded house of over 400 dons, probably a more difficult audience than the House of Commons.

It is not generally known that the Radcliffe Climatological Station is under the direct control of the Professor of Geography. Meteorological observations have been taken systematically at this station since 1815. In 1935, when the Radcliffe Astronomical Observatory was moved to South Africa, meteorological observations at the site became the responsibility of the Professor of Geography, and the old meteorological library was transferred to the School. The Observatory building is one of the most interesting pieces of eighteenth-century architecture in Oxford. Since the retirement of Mr. J. G. Balk in 1954, after more than fifty years of service as Radcliffe Meteorological Observer, the daily observations have been carried out by A. C. Martin, clerk and photographer of the School, under the supervision of C. Gordon Smith. Mr. Balk's death in 1957, after less than two years of retirement, was deeply regretted in the School. The Radcliffe Climatological Station was recently inspected by the Meteorological Office and the official report stated that "the high reputation which the station has earned in the past is being maintained." It is fully intended that the long tradition of the School's climatological research built up by H. N. Dickson, A. J. Herbertson and W. G. Kendrew shall be continued and developed.

E. W. GILBERT

UNIVERSITY COLLEGE OF SWANSEA

Although a full honours degree course in geography is of recent establishment in the University College of Swansea, the subject, in association with geology, has featured in the life of the College from its foundation in 1920. Initially, special geography courses for teachers were given by Dr. A. E. Trueman and by S. W. Rider. In 1931, D. Trevor Williams, reader in geography at the University College of Exeter, was appointed the first lecturer in geography within the newly named Department of Geology and Geography and courses were offered in geography to the final (pass) level. Mr. Trevor Williams, having been assisted by M. L. T. Sinclair and Miss P. B. John, left in the session 1945–6 to join the Ministry of Town and Country Planning. B. H. Farmer succeeded as lecturer but left in 1948 to take up a fellowship at St. John's College, Cambridge. J. Oliver, then at University College, Dundee, was next appointed with the assistance of Miss G. E. Groom from Birmingham.

The courses in geography were still limited to the subsidiary and final levels and administratively geography remained within the joint Department of Geology and Geography. The numbers taking geography, however, continued to rise steadily and the need for an honours course was recognized in 1953. F. V. Emery from Oxford was added to the staff as an assistant lecturer and geography was provided with newly equipped and separate lecture rooms, laboratory and technical accommodation. Complete recognition of the subject within the College was finally achieved in 1954 with the establishment of a Chair of Geography and the creation of a separate department. Dr. W. G. V. Balchin, then lecturer at King's College, London, was appointed professor of geography and head of the new department.

Since 1954, the main effort of the new department has been directed into the formulation of courses at various levels in both arts and science faculties, and to the planning and equipping of the new accommodation within the natural science block which was scheduled to house geography, geology, botany and zoology. The move to the new building was made in September of 1956 and the accommodation now available to geography consists of a large general laboratory, a smaller honours laboratory, a lecture theatre seating sixty, a set of dark rooms, an office, a workshop

and cartographic room, a map library and individual rooms for all members of staff. There is also a joint library and a large joint lecture theatre common to the four departments within the Natural Science block. The long continued interest in geography, dating back to the beginning of the college, has given a good foundation to the library and map collections, and to these extensive additions have been made in the last two years. The department is also rapidly becoming well equipped in surveying, photogrammetric, meteorological and cartographic apparatus.

Courses are offered in both arts and science faculties to final (pass) and honours levels, whilst auxiliary and accessory students are also catered for. Student numbers have continued to grow and entry is now competitive and selective. As well as providing basic training in geography the department encourages research and contributes towards vocational training by the development of specialized options of which each honours student must select one for advanced study. Geomorphology, climatology, cartography, historical geography and economic geography are currently being developed. The introduction of cartography represents an interesting innovation as this essential aspect of the subject has not hitherto been studied to an advanced level in other universities in the United Kingdom. The completion of the second stage of the natural science building during the next quinquennium will more than double the space available to the department and it is then hoped to develop further specialist topics within the scope of geography. Advantage is taken of the favourable position of Swansea to achieve a close balance between field work, library work and laboratory work in both graduate and undergraduate activities. The Gower peninsula is a natural field laboratory illustrating a wide range of normal and coastal processes of erosion and accretion whilst the immediate hinterland demonstrates normal and glaciological morphology. South Wales as a whole also exhibits a wide variety of dynamic economic, and historic landscape changes. Swansea is probably unique in having so close at hand such a great variety of terrain available for both field work and research. A considerable amount of field work is therefore undertaken in all courses and the department is fortunate in having available adequate transport facilities for the movement of both apparatus and personnel.

Members of the permanent teaching staff now include J. Oliver, who specializes in climatology; Miss G. E. Groom, who specializes in geomorphology; Dr. D. H. Maling, who specializes in cartography and S. H. Cousens, who is responsible for historical geography. Professor W. G. V. Balchin maintains his own particular interest in geomorphology and cartography. There are also tutorial assistants and research demonstrators to assist in the teaching. All members of the lecturing staff contribute to the regional teaching, and the department is fortunate in having first-hand knowledge of most European countries, North and South America, Africa, South-east Asia and both North and South Polar regions. W. G. V. BALCHIN

THE GEOGRAPHICAL ASSOCIATION

The Annual Conference was held at the London School of Economics from January 1 to 4, and was notable for the very valuable programme of lectures and addresses that were included and for the large attendance of members. To the Council of the Royal Geographical Society we were greatly indebted for tea and the hospitality of its house on the first afternoon, when our President, Lord Nathan, gave his Presidential address on "Aviation and geography" to a crowded joint meeting of the Association, the R.G.S. and the I.B.G. His address was a comprehensive survey, drawing attention first, to the importance of aviation in relation to polar exploration and to survey and mapping generally, and then by contrast, to its value through air photography, in many fields of research in historical geography; the latter were illustrated with striking air photographs. Lord Nathan followed with a summary and illustration of aspects of the application of aviation to research in economic geography (especially with reference to the work of the Commission on World Land Use, founded in 1949) and with reference to the survey of mineral resources. The value, also, of

airborne techniques was shown in speeding up research into the world's soil and plant resources in the surveys of regions such as the Indus valley and 'Iraq, and equally in regions of more developed extensive agriculture, as in the U.S.A. or New Zealand, where "agricultural aviation" plays an important role in pest control, soil and fertility maintenance, etc. A more specialized use of aviation, and one of growing importance, was referred to in the air-beef scheme of freight transport that may revolutionize meat exporting facilities in less accessible parts of Australia. The address, which will be published in the January issue of *Geography*, concluded with discussion on the relevance of aviation as a factor in changing regional values, as illustrated in northern lands in Asia, Europe and North America. We are greatly indebted to our President for so stimulating an address on a subject of great and ever growing importance, and one that has brought rapid and dramatic changes of geographical significance the world over.

The conference programme included other lectures by academic geographers, including three of special note—by Professor Balchin on "Britain's water supply," by Professor Buchanan on "Impressions of Brazil," and by Professor Linton, who gave a thought-provoking and timely address on the role of geography in relation to the present social revolution. The importance of field work was exemplified by a demonstration lesson with grammar school boys (watched by some 400 members), and a lecture on the work of the summer school in Guernsey held last summer under the direction of Dr. Briault. In view of current interest in polar exploration, there was a lecture on modern Antarctic exploration given by Mr. Walton, and a showing of the forty-two-year-old film of Shackleton in the Antarctic, by Sir James Wordie. The International Geophysical Year was reported on by the secretary of the Royal Society, Dr. Martin. To this programme of lectures there were added others, with associated field excursions; also a valuable discussion was held on "Geography and a liberal education," led by Mr. Warren (Principal of the South East London Technical Institute) and Dr. Briault. To the two conference organizers (Mr. Honeybone and Dr. J. H. Bird) our warmest thanks are due for not only a programme of outstanding quality and interest, but also for the valuable publishers' and visual aids and maps exhibitions that each year provide so useful a service for teachers of our subject, and a background to the conference.

ALICE GARNETT

THE 18TH INTERNATIONAL GEOGRAPHICAL CONGRESS, RIO DE JANEIRO 9–18 AUGUST 1956*

About twenty-five delegates from the United Kingdom attended the 18th International Geographical Congress at Rio de Janeiro from 9–18 August 1956. The meeting was generously supported by the Brazilian Government and many other authorities. The Congress itself was housed at the Escola Naval, and a number of delegates from all countries were also lodged there. The President of the Congress was Professor Dudley Stamp, and local arrangements were admirably made by the Brazilian National Committee under the Chairmanship of Jurandyr Pires Ferreira. To Professor Hilgard O'Reilly Sternberg, of Rio, all geographers owe a great debt: his enthusiasm and wide knowledge, not only of the infinite detail that is involved in arranging such a congress, but also of the geographers attending, helped most effectively to make the first congress to be held in the Southern Hemisphere a great success. Everyone who attended will have vivid memories of the kindness and generosity of his Brazilian hosts. The President of the Republic received members on August 9, and later the same evening addressed the opening meeting in the Municipal Theatre. Receptions were held in the Itamorati Palace, the Yacht Club, and the Ipica. His Eminence the Cardinal Archbishop of Rio de Janeiro, on behalf of those attending the Congress, celebrated a Te Deum shortly before the final meeting. The British delegation were entertained by our Ambassador and Lady

* This account has been compiled by Professor J. A. Steers: Professor Austin Miller, Dr. Eric Brown and Dr. Eila Campbell contributed notes on certain sections.

Thompson, and also by Mr. and Mrs. Bottrall on behalf of the British Council. Sir Geoffrey Thompson's personal help in all that concerned our own delegation was greatly appreciated. There were 13 sections, many of them meeting conjointly, at which 247 papers were offered.

Section 1: *Cartography and Photogeography.*—Professor Wreford Watson (Edinburgh) was co-chairman of Section 1, and it was noted that a good deal of progress had been made in thought and technique since the Washington Congress. Many of the papers were concerned with aerial photography—several of them relating to the representation of geomorphological data (*e.g.* Hans Annaheim of Switzerland).

Section 2: *Geomorphology.*—The section met for a total of 15 hours, and geomorphological commissions met for a further 16 hours to hear reports on work carried out since 1952. The quality of the sectional papers varied a good deal. Outstanding contributions were made by several French geographers, including those working in North Africa on the problems posed by land forms in arid and semi-arid regions. The growth of geographical studies in Brazil, where there is a small but active group of geomorphologists, was demonstrated not only in the lecture room but also on the field excursions. The English-speaking world of geomorphology was conspicuous by its relative absence, a state of affairs which must be remedied at Stockholm in 1960. German work in the developing field of climatic geomorphology was well received.

Section 3: *Climatology.*—Under the chairmanship of Professors Hans Kinzl and Austin Miller the climatology section held three rather congested sessions and heard about twenty papers on topics as difficult to classify as are climatic types themselves. The climatology of tropical and sub-tropical regions attracted the greatest number of entries, partly because these climates occur over more than half of the earth's surface, but also because the Congress was being held for the first time in a tropical country—though to be sure the weather of the Rio winter was much less tropical than that we met in the "temperate" climate of Washington in August 1952. Of the ten papers that might be classified in this group seven related to South America and were welcome contributions to our understanding of a continent hitherto much neglected in climatic study. As was quite proper at a geographical congress the regional approach was generally adopted even in papers professing primary concern with climatic classification; climate was, in fact, treated as a geographical factor and there was pronounced emphasis on the influence of climate on man's activities, though there was one paper (from the U.S.S.R.) which placed the boot confidently on the other foot and claimed the control of climate by man.

Section 4: *Hydrography.*—Only four papers were offered in Section 4. It is a pity that this subject, often so relevant to geographers, was not better supported.

Section 5: *Biogeography.*—Although two of the leading European plant geographers (Carl Troll and Henry Gaussen) were sharing the chairmanship of the section there was only one paper on European biogeography. Seven of the ten papers on the programme were concerned with South America and five of them were about Brazil—thus emphasizing what a happy hunting ground it is for foreign plant-geographers. South America (especially in its forests) provides the finest and most extensive survivals to be found of natural vegetation unaffected by man. Kurt Hueck (Germany), who has worked in the Serra da Mantiqueira, communicated his surveys of three altitude zones: *Podocarpus* and *Araucaria* forests; the natural high level grasslands (campos) of the Campos de Jordão; and the almost periglacial peat-bogs (Hochmoor) near Itapeva Peak on the highest parts of the Serra do Mar. Richard Momsen (U.S.A.) also devoted attention to the critical boundary between forest and grassland zones on the Brazilian Planalto Central. Karl Arens (Brazil) offered a paper on the dense forests of babacu palms in the north of Brazil, and J. Chebataroff (Uruguay) on the vegetation of Uruguay and Rio Grande do Sul. Many of the papers presented by Brazilians in the climatology section showed a sensitive appreciation of bioclimatic relationships.

Section 6: *Human geography.*—In Section 6, eighteen papers were offered, and ranged over a wide field, but there were no contributions from the United Kingdom. Some of the papers were complementary to those offered to the Hydrology Section, *e.g.* those concerning problems of water supply and irrigation.

Section 7: *The Geography of population and settlement.*—This section was certainly popular. Its papers ranged from the geography of commuting, through several studies of Brazilian geography, to a discussion of the immigration problem. In all, more than 50 communications were listed, but less than 40 were given. Dr. Amiran's (Israel) paper—"The expansion of settled land in Israel"—was an important contribution.

Section 8: *Medical geography.*—The growing interest and significance of medical geography—not perhaps the best of titles—was manifested in Section 8. The mapping of the distribution of diseases is a matter with which geographers are much concerned, and there are correlations to be made with climate, soil, water and other factors of the habitat.

Section 9: *Agricultural geography.*—There was a wide variety of papers in this section, ranging from Hans Boesch's "drei Zelgen" system in north-east Switzerland, through detailed studies of several countries, to such general themes as the "social fallow," an index of geographical differentiation of the landscape. J. P. Haughton of Dublin contributed a paper on contemporary changes in the Irish rural landscape.

Section 10: *Economic geography.*—This section also had a wide appeal, and included communications of substance from Stanley Beaver, Oskar Spate and Chauncy Harris. Another interesting topic was that of transport problems in Canada. One paper by P. Monbeig (France) was concerned with the geographical aspects of investments in Latin America.

Section 11: *Historical and political geography.*—The programme was so arranged that papers in historical geography, political geography, and the history of cartography were presented in the same section. The section held two meetings, presided over by R. L. Singh (India) and O. H. K. Spate (Australia). There was an interesting group of papers on the siting of capital cities. Two Brazilian authors presented a careful study of the Parana–São Paulo state boundary, and three delegates from Japan gave evidence of the lively interest in political geography in Japan. R. J. Harrison Church's paper on our Trusteeship in Togoland was important. Different in character from these political–historical themes was a discussion of the changing forms and functions of the road from Acapulco to Vera Cruz, by R. L. Stevens, who had followed along Humboldt's route in the field, and Eila Campbell's review of the source material available for a reconstruction of the Filipino scene in the first half of the nineteenth century. There were also three papers in the history of cartography. The authors would have had a more worthwhile hearing had they presented their papers to the Commission on the Bibliography of Ancient Maps. The audience of Section 11 contained too large a proportion of non-specialists to encourage critical public discussion of many of the papers presented.

Section 12: *Methodology.*—In the discussions on methodology, teaching of geography, etc., a good deal of attention was paid to the training of professional geographers. Little was said about bibliography, the other subject placed in this section.

Section 13: *Regional geography.*—This last section attracted few papers, but amongst them those of Salvador Massip on Cuba, and Lewis Robinson on Canada provoked considerable interest.

The reports of the several commissions appointed at Washington gave rise to some of the most interesting meetings and discussions. One reason for this was, perhaps, that for the most part only specialist audiences attended these meetings, so that questions and debates could develop between those directly interested. It is noteworthy that in some cases there were insufficient copies of the reports for all members

of the Congress. This was inevitable on account of the high cost of printing and paper, but it was nevertheless a pity.

At the end of the meeting eleven Commissions were reappointed—The Arid Zone, Bibliography of Ancient Maps, Coastal Sedimentation, Erosion Surfaces around the Atlantic, Evolution of Slopes, Teaching of Geography in Schools, Inventory of World Land Use, Karst Phenomena, Library Classification of Geographical Books and Maps, Medical Geography, and Periglacial Morphology. Two Official Commissions were also appointed—Mapping of World Population, and the Humid Tropics.

Before and after the Congress nine excursions to various parts of Brazil were arranged. All who enjoyed these excursions had the opportunity of appreciating the reliance now placed on air transport in this vast and rapidly developing country where the growth of skyscraper cities has overtaken the efforts to link them by modern highways. Everywhere the parties were met with lavish and cordial hospitality. There were excellent guide books—in French and English—prepared for certain of these journeys. There were also local excursions during the congress in and around Rio de Janeiro.

Two large rooms in the Ministry of Education had been set aside for general meetings and for an exhibition of maps and books. The evening meetings on Brazil were well attended, and the open discussions on "Problems on grasslands in tropical regions" (under the chairmanship of J. Chebataroff (Uruguay)) created a great deal of interest, as also did that on the "Contribution of geography to the regional planning of tropical areas," when Dr. Harrison Church (U.K.) took the chair. At these, and at the meetings of the general assembly, simultaneous translation was provided.

The map exhibition was comprehensive. The Russian wall maps and atlases were admired, and our own maps were well shown and had been carefully chosen. The collection of books on geography arranged by the British Council and the Royal Geographical Society was most successful. The Society was also responsible for co-ordinating the U.K. map exhibition. The Brazilian maps and pictures, because of their much greater number were housed in the Aeronautical Club; the Conselho Nacional de Geografia was responsible for the largest section.

In all, just over 1000 delegates attended the Congress, representing 45 countries and the United Nations. The British delegation was fourth in order of size. At this Congress a new statute was approved under which associate membership of those countries (French West Africa, 'Iraq, Kenya, Nigeria, Sudan, Uganda) with but a small number of professional geographers was established. Associate members have no vote on administrative matters. The U.S.S.R., Ethiopia, Iceland, and Hungary became full members. The request of the German Democratic Republic for membership was left over until the next general assembly. Meanwhile, certain of the statutes governing the International Geographical Union are to be reviewed.

The next Congress is to be held in Stockholm in 1960. The five northern countries —Denmark, Finland, Iceland, Norway and Sweden—will be our hosts. Professor H. W. Ahlmann (Sweden) has been elected President. The Vice-Presidents are Hilgard O'Reilly Sternberg (Brazil), Hassan Awad (Egypt), Chauncy D. Harris (U.S.A.), Maximilien Sorre (France), L. Dudley Stamp (U.K.), Fumio Tada (Japan), and Carl Troll (Germany). Hans Boesch of Switzerland succeeds George Kimble as Secretary-Treasurer, and the Secretariat is now established at Freiestrasse 30, Zurich 32, Switzerland.

I.G.U. REGIONAL CONFERENCE

The International Geographical Union's Regional Conference in Japan this year, from August 29 to September 3, is being organized in cooperation with the Science Council of Japan. Excursions have been arranged before the conference opens to Hokkaido and Tohoku, and after its close to Tokai-Tosan and Setouchi. The conference will meet in Tokyo and in Nara, and a "First Circular" points out that this

will be the first geographical conference to be held in the Far East. The address of the Secretariat of the Organizing Committee is Science Council of Japan, Ueno Park, Tokyo (Cables, Sciencouncil Tokyo), and papers concerning the conference may be consulted in the Society's library.

THE TELLUROMETER SYSTEM OF DISTANCE MEASUREMENT

We print below a summary of the paper to be read to the Society on Wednesday, April 24, by T. L. Wadley, on the Tellurometer system of distance measurement. A full account of the system is to be published in the *Empire Survey Review* for July and October (Nos. 105 and 106) and it is hoped offprints will be available on April 24, before Mr. Wadley's lecture.

The Tellurometer system is a radio microwave (3000 Mc/s) distance measurement system developed for geodetic and other survey purposes. The instrument measures slope distance in any conditions of visibility provided reasonable line of sight conditions exist. The range of the instrument is about 30 miles, or somewhat greater or less depending upon topographical conditions. The accuracy on a single line measurement is stated to be about 2 inches on account of instrumental resolution plus 3 parts per million on account of meteorological effects, in average weather conditions and average conditions of topography. Measurements are made between two sets of portable instruments each weighing a total of approximately 32 lbs. The instruments may be elevated on relatively simple structures of minimum stability where necessary as no precise alignment is necessary.

The technique of measurement is a phase measurement of a modulation of the microwaves as these leave the focus of the Measuring end, or Master, parabolic mirror, relative to a similar but more complex modulation, at this mirror focus, returned from the Remote station. Four modulation frequencies are used of the order of 10 Mc/sec in such a way that an unambiguous measurement is obtained provided the distance is known to within 10 miles. A method using what are referred to as positive and negative measuring patterns is used to free sensibly the system from zero errors, and reverse phase readings to free the phase display from centreing errors.

The effect of meteorological conditions has been investigated and it has been concluded that uncertainties in the mean temperature of the path account mainly for the limits of accuracy and, to a lesser extent, humidity effects. The latter are found to be less severe than might be anticipated. The effect of ground reflections has been investigated. These are found to cause very little error on the majority of lines measured, as the microwaves are effectively scattered by most ground surfaces. A technique of measurement on a series of carrier frequencies has been developed which effectively removes such errors where they occur. Such effects are most severe when the path is partly over water surfaces, and these effects and the greater uncertainty of meteorological conditions over water, result in somewhat lowered accuracy, although measurement approaching geodetic accuracy has been made in such conditions.

Measurements of three trigonometric figures having a number of redundant lines have been made in varying meteorological and topographical conditions. A least squares-adjustment of the measured figures for self consistency, and a comparison with the trigonometric data have provided the information on which the stated accuracy is based. In two cases where the figures straddle a trigonometric base line, an accurate estimate of the velocity of electromagnetic waves has been made, giving figures of 299,793·1 Km/s and 299,792·9 Km/s respectively in vacuo, the probable error being estimated at $\pm$·5 Km/s. In the third case, where the figure was well away from a base, an estimate of the deviation of the trigonometric scale has been arrived at.

The instrument was designed primarily for geodetic work either as a means for laying down bases in preference to taping or, alternatively, to replace triangulation by

An experimental model of the Master Tellurometer measuring a line between beacons in Pretoria and Johannesburg

trilateration in circumstances of permanent poor visibility or where otherwise advantageous. On account of its high portability it is considered that the instrument may have uses in other fields even where the full accuracy is perhaps not necessary, such as controlling the scale of aerial photography, mapping work in general and coastal traversing for hydrographic purposes. In shorter range work the instrumental accuracy becomes the limiting factor, but the instrument might also have uses in this field.

DURHAM UNIVERSITY EXPLORATION SOCIETY

The Durham University Exploration Society has published an excellently produced "Report of the expedition to French Morocco 1952," well furnished with maps, illustrations and diagrams. The expedition consisted of four sections; archaeological, geographical, botanical and zoological. The latter conducted ecological surveys of the flora and fauna of the Massif Tichehoukt, about 90 kilometres south of Fez, the archaeologists examined the remains of the Roman Imperial frontier, and the geographers studied rural settlements in various parts of the French Protectorate. The whole report, which is in varitype and bound, contains 166 pages. Copies may be obtained at a cost of 12*s* 6*d* (including postage) on application to Dr. David Smith, Romano-British Museum, King's College (University of Durham), 11, Sydenham Terrace, Newcastle upon Tyne, 2. It may be possible to meet requests for offprints of one or more of the sections mentioned.

SOVIET SERIALS IN THE SOCIETY'S LIBRARY

BULLETIN (IZVESTIA) ACADEMY OF SCIENCES OF THE U.S.S.R. GEOGRAPHICAL SERIES, 1956, No. 5 (September–October). Obituary of V. A. Obruchev, by E. M. Murzaev. Formation of marine terraces, by A. S. Ionin and P. A. Kaplin. Physical geography in regionalization of the Tuva autonomous oblast, by B. N. Likhanov. Problems of the development of production in northern Caucasus during the sixth Five-year plan, by E. P. Maslov. Geography of production in Czechoslovakia, by M. Blazek. The 75th birthday of N. N. Baranskii, by I. M. Maergoiz. Water balance in irrigated territories, by L. V. Dunin-Barkovskii. Variations in the temperature of the air during the 19th and 20th centuries in the East European sector of the Northern hemisphere, by M. E. Lyakhov. Traces of an ancient hydrographic network in the basin of the central Yenisei, by S. R. Itskanov. Geomorphological mapping in Poland, by A. I. Spiridonov. Toponymics and the transcription of geographical names of the Latvian S.S.R., by V. R. Purin.

BULLETIN (IZVESTIA) ALL-UNION GEOGRAPHICAL SOCIETY, vol. 88 (1956), No. 5 (September–October). A. Karabaili's work in Aral sea, by R. S. Dengina. The geographical ideas of G. F. Morozov, by A. G. Isachenko. Laboratory and practical work in physical geography in teachers' training institutes, by Y. D. Dmitrevskii. New elements in the development and distribution of the dairy industry in the Novosibirsk oblast, by N. M. Kolobkov. Karst in the area of the Volga basin in the Tatar A.S.S.R., by M. S. Kaveev. Review of the first Soviet meteorological dictionary. Second conference on landscape, by A. G. Isachenko. Ukrainian geographers conference on the tasks of Soviet geography in the Ukraine in the light of the 20th Congress of the C.P., by A. S. Kharchenko.

AN ICE-MARGIN LAKE IN ICELAND

The object of this note is to place on record some changes in topography resulting from recent recession of the Langjökull ice cap in central Iceland. The account of the 1934 Cambridge Iceland Expedition (*Geogr. J.* 86, 3 (1935) 218–34) includes a description and a map of an ice-margin lake—Þorisdalurvatn—on the south-west edge of Langjökull. This lake was one of a number surveyed by that expedition during their study of a glacial overflow channel. In 1953, Þorisdalurvatn was resurveyed by the Iceland Expedition of the Brathay Exploration Group and the results

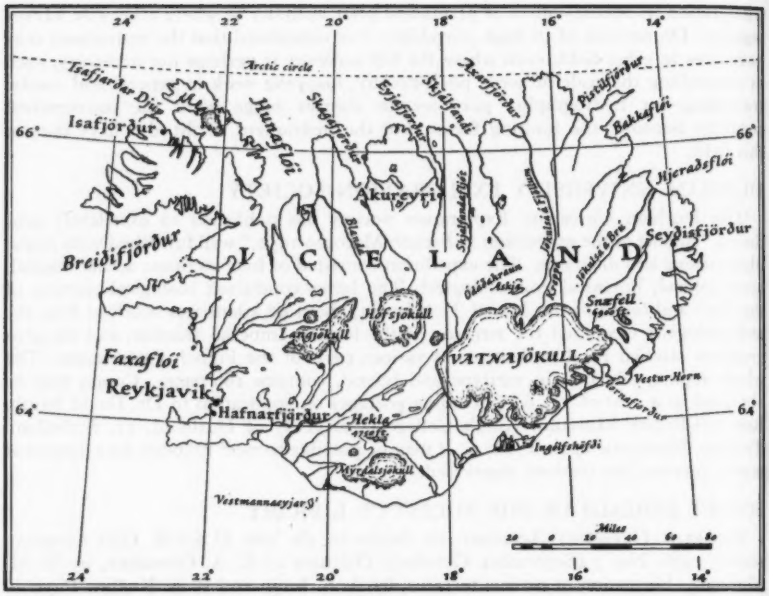


Figure 1

show clear and precise evidence of glacial retreat since 1934 and its effects upon the size and shape of this lake. Additional information on the rate of this retreat can be obtained from the evidence given by air photographs taken in 1937–8 and 1946. The outlines shown on these photographs are here reproduced together with those of the 1934 and 1953 maps. There was no time for more than a quick survey of the lake and so no speculation will here be made on reasons for the minor alterations in shape. It is hoped that the 1953 map, which is on a far larger scale than any previous maps, may serve as a useful basis with which future large-scale surveys of the lake may be compared (see also p. 130).

Method of survey.—A compass traverse was made using a 100-foot linen tape and a liquid prismatic compass. The recorder of the readings, which were made as near to the edge of the water as possible, also made a sketch of the position of the water's edge relative to the taped line and noted the nature of the surroundings. The accuracy may be judged from the fact that on the main traverse circuit of over 8 kilometres the closing error was only 18 metres.

M. W. DYBECK

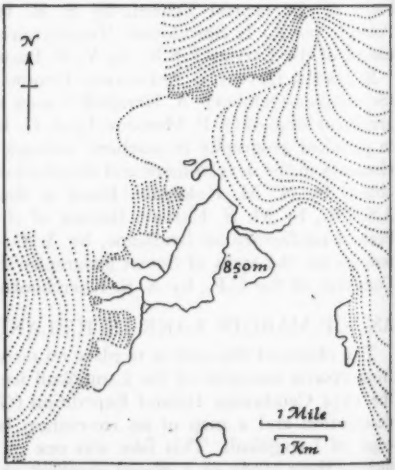


Fig. 2. Map of 1934 Cambridge expedition

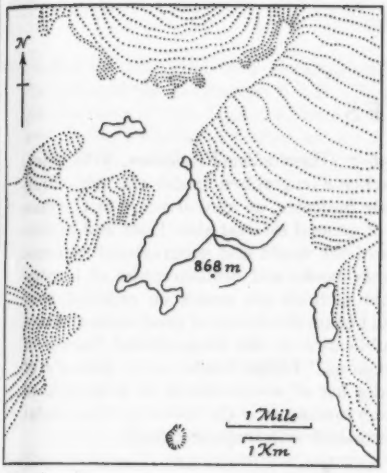


Fig. 3. From Danish Geodetic Institute map, 1938

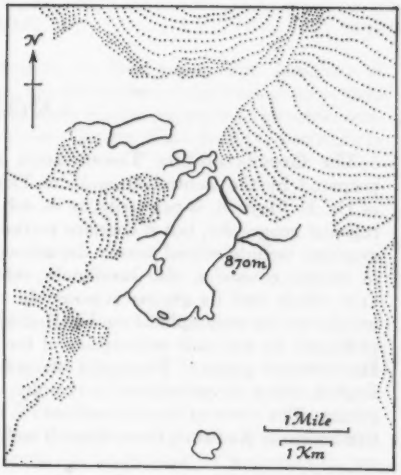


Fig. 4. From air photographs, 1946

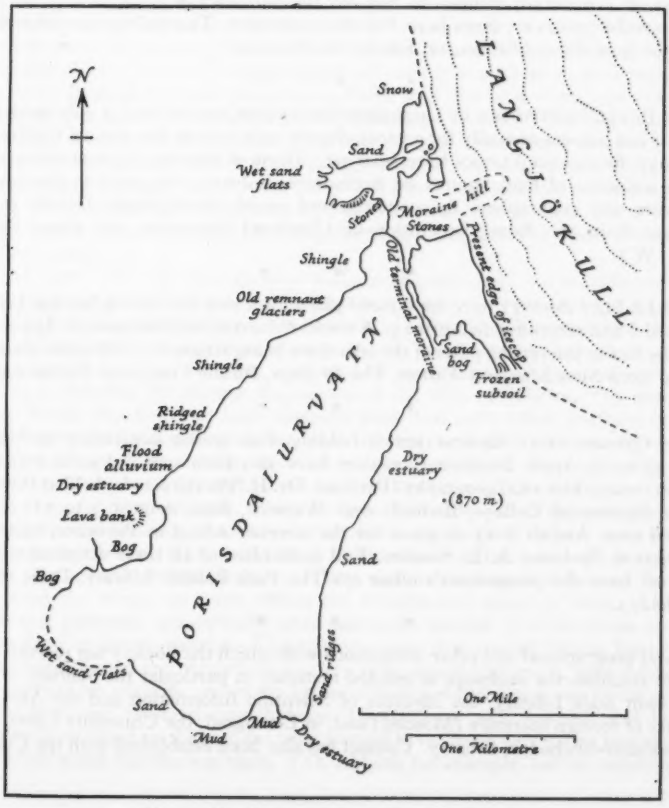


Fig. 5. Brathay Group map: August 1953

NOTES

The GEOGRAPHISCHES TASCHENBUCH 1956–7 (*Wiesbaden, F. Steiner*, DM.9.80), prepared by the Zentralverband der Deutschen Geographen under the editorship of Dr. E. Meynen, is primarily, as its sub-title indicates, an annual guide to German regional geography, but it contains sections of general interest also. Lists and bibliographies include official survey departments of the world and geographical societies in various countries, also handbooks, reference books and bibliographies of Europe as a whole and its greater regions. In other sections are essays on regional geography and on geographical method, including one on the theory of geographical zones prompted by the 50th anniversary of the publication in the *Geographical Journal* of Herbertson's paper, "The major natural regions." Other items are a glossary of English terms in agricultural geography, and a list of abbreviations of geographical names. The value of these handbooks is much increased by the inclusion of cumulative indexes. As usual, the volume is well furnished with maps in colour.

* * *

Messrs. EDWARD STANFORD LTD. have drawn attention to their periodical bulletin dealing with map publications. No. 10, July 1956, covers official foreign and colonial surveys. It is generally difficult to find out the publisher of a map and its price; as far as possible prices are given here, but not publishers. The bulletin can be obtained post free from the publishers, 12, Long Acre, W.C.2.

* * *

The ROYAL INSTITUTION OF CHARTERED SURVEYORS has initiated a gold medal and prize of 100 guineas annually for a paper chosen to be read at the Annual Conference. For 1957, four general topics have been set. Those of interest to geographers relate to the influence of land tenures on agriculture, industry, etc., and to the work of surveyors and geographers in economic and social development. Details can be obtained from the Royal Institution of Chartered Surveyors, 12, Great George Street, W.1.

* * *

The LE PLAY SOCIETY have announced plans for a visit to Corsica, leaving London on April 8 and returning on April 24. A week of the time will be spent at Ajaccio and tours by bus to interesting parts of the island are being arranged. Full particulars may be had from Miss Margaret Tatton, The Birlings, Birling Gap, near Eastbourne.

* * *

The GEOGRAPHICAL ASSOCIATION is holding their spring conference at Matlock from 23 to 27 April. Preliminary notices have also been sent out of two summer schools: one in historical geography (Director, Dr. H. Thorp) is to be held at Westham House Residential College, Barford, near Warwick, from August 3 to 17. A provisional date, August 8–23, is given for the summer school in Provence, under the direction of Professor A. E. Smailes. Full particulars of all these activities may be obtained from the Association's office c/o The Park Branch Library, Duke Street, Sheffield, 2.

* * *

Soviet geographical and other institutions with which the Society has recently been able to establish the exchange of printed material, in particular the *Journal*, include the Lenin State Library, the Institute of Scientific Information and the All-Union Library of foreign literature (Moscow) and, in Leningrad, the University Library and the Saltykov-Shchedrin Library. Contact has also been established with the Crimean

section of the All-Union Geographical Society, in Simferopol. The Academy of Sciences of the Lithuanian S.S.R. (Vilnius) has also agreed to provide geographical publications for the Society's library. Attempts are still being made to establish contact with provincial branches of the All-Union Geographical Society, particularly those in Siberia and the Ukraine.

* * *

OBITUARY

CAPTAIN V. L. A. CAMPBELL, D.S.O., R.N.

1875–1956

As the only survivor of the Northern Party of Scott's last expedition it is right that I should have the opportunity of paying tribute to our leader Victor Campbell who has died in Newfoundland, in November 1956, at the age of eighty-one. We lived together intimately in the Antarctic for two years during which we experienced a variety of physical and mental adventures such as falls to the lot of few men in ten times that length of time. Victor was one of the "hungry hundred"—the batch of merchant service officers who were admitted to the Royal Navy during a period of expansion about the commencement of the century. He had therefore the advantage of both sets of experience, including square-rigged sail, which stood him in good stead. He was a quiet unassuming man but imperturbable and firm and there was never any doubt who was in command when he was about on his lawful occasions in his own unit. I had every opportunity of knowing this. The Northern Party consisted of six men; two of them naval officers, three naval seamen of the long service type, caught young and meticulously trained for many years in a specialized environment, and myself, the only civilian. Naval men of that particular vintage were the salt of the earth but they needed knowing and sympathetic and firm handling under the unusual Antarctic conditions.

Victor would not have been an ideal leader on a polar dash, but for this particular job, as it developed, he approached the ideal very nearly. In 1911, at Cape Adare, we were physically as comfortable as it is possible to be under polar conditions, but our leader, at any rate, was subjected to considerable mental strain through frustration of one kind and another. To begin with, we had been summarily deprived of our first home and objective by finding Amundsen at the Bay of Whales. The proposed Eastern Party, which was to have explored King Edward's Land, perforce became the Northern Party. Again, pack ice, bad weather, and time limitations, together compelled Campbell to a choice between returning with the ship and landing at a place on the Victoria Land coast where we knew that it would be unlikely we should be able to get far from our base. The polar quest had absorbed all the available transport animals and vehicles and we were limited to manhauling. Where we wintered, the plateau was bordered by a solid block of mountains without through glaciers and the sea ice in and around Robertson Bay was notoriously treacherous. In fact, throughout the winter we were seldom out of sight and sound of what, to all our intents and purposes, was virtually open sea—open enough to allow waves of some size to form in heavy weather. Through the year that ensued Victor kept us all occupied and happy and we left in January 1912 a well-knit party, reasonably well satisfied with the scientific record we had achieved, to which every one of the six had made notable and essential contributions. I sometimes used to think that he was occasionally too hard on the men for what seemed to me to be very minor peccadilloes, but I know today that he was right. P.O. Abbott, for example, had no memory and

was always getting into what I thought was too hot water for mislaying gear of all sorts. In the twenties he was to lose his life through an illness that stemmed directly from this particular—not fault, but weakness.

In 1912 the Northern Party were really tried. Marooned at the stormiest place in Victoria Land in this the stormiest recorded year in Antarctic history, we spent eight months living in a hole in the snow on one month's sledging provisions and what we could pick up locally, and in summer clothes. It was an experience that might have broken the strongest team. That we survived, most of us in good fettle, was largely due to our leader's quality. We started off, as soon as we had dug out a cave home, by a general discussion in which it was clearly laid down that all major problems should be freely discussed from all angles by all hands as long as they wished, but that, when discussion had ended, Campbell's word went. In our squalid little home an imaginary line bisected the 12-by-9-foot floor. One half was the messdeck, the other the quarterdeck. It was no matter of underlining class distinction. Anything the men said on their side of the line could not be officially overheard on the other. They were far too good fellows to criticize us specifically—but we heard many stories about officers with whom they had formerly served from which we were expected to draw the moral. What we heard was very good for our souls and made us far better handlers of men when the lessons had sunk in, as they did.

Part of our mental recreation was naturally drawn from past experience, and here Campbell was a tower of strength. He had a great sense of humour. It was during this winter that I learned of the near-mutiny in a squadron on the Pacific coast because the matelots were fed turkey and salmon and insisted upon their statutory ration of salt pork. I remember too his description of the visit of the First Cruiser Squadron to New York when the liberty parties found the city placarded with newspaper posters which read "We must be hospitable to our English cousins: the only foreign nation that speaks our language."

He organized us in three teams, each of one officer and one man, to do our daily chores and no one could surpass him in cheerfulness or efficiency at work either as housemaid or cook. He never let us down then or later, though at the time I deprecated the extreme shyness that forced me into prominence as historian and public relations officer of the party and eventually made me something of a specialist in polar lore.

RAYMOND PRIESTLEY

DERWENT STAINTHORPE WHITTLESEY

1890–1956

The sudden death of Derwent Whittlesey of heart failure on November 25 a few days after his sixty-sixth birthday has robbed the world of one of its leading academic geographers. Born at the village of Pecatonica in the State of Illinois on 11 November 1890, he received his undergraduate training at the University of Chicago, graduating PH.B. in 1914, and M.A. in 1915. Apart from one year (1915–16) as acting assistant professor of history at Denison, and two years with the Army in 1918–19, the whole of Whittlesey's adult life was associated with but two universities—his alma mater of Chicago, where he was successively instructor, assistant professor and associate professor (1919–28), and Harvard where he went in 1928, becoming full professor in 1943 and where he was still lecturing at the time of his death.

The geography school at Chicago under Harlan Barrows will always be associated with the concept of geography as human ecology, in contrast to other schools which tended to regard geography as an offshoot of geology. Whittlesey's fine appreciation of scholarship saved him from accepting the short cuts and facile correlations which mar the work of some "human" geographers. This is seen in his early books—'The major geographical regions of North America' (with M. C. Stark, 1923) and his 'Introduction to economic geography' (with W. D. Jones, 1925). Especially through

the Association of American Geographers, of whose *Annals* he was for many years (1930–43) editor, before becoming President in 1944 and Honorary President in 1954, he attempted to preach the virtue of quality not quantity. He sought to restrict membership of the A.A.G. to a select few, and later at Harvard his aim was to maintain a small, highly selected graduate school. Unhappily his A.A.G. policy led to the establishment of a rival body, later amalgamated with the A.A.G., with a more liberal or elastic membership policy, whilst at Harvard his policy led indirectly to the elimination of the department of geography as an economy measure.

Like many other confirmed bachelors, "Whit" was a shy man rather than a misogynist. To those friends who were privileged to enjoy the hospitality of the Harvard apartment, rich with objets d'art from many lands, which he shared with his life-long friend and colleague Kemp, he was a charming host, with a keen appreciation of the almost lost art of gracious living. In his academic life he turned to the intricacies of political and strategic geography, latterly with a special interest in Africa (he held a Fulbright Travelling Fellowship to tropical Africa in 1951), but in their private lives he and Kemp spent long periods wandering leisurely through Europe, sampling wines and assessing culinary achievements to be reproduced later at home. Unhappily the gastronomic map of Europe which was once planned never appeared.

The story of geography at Harvard is a sad one. The natural development of a separate department was not helped by the establishment of an independent Institute of Geographical Exploration, in a fine building built, magnificently equipped and maintained by Dr. Hamilton Rice, who was accorded the status of professor though his academic training was in medicine. Nevertheless Whittlesey had gathered round him a band of brilliant young geographers when the blow fell. At the time when J. B. Conant, as President of Harvard, was preaching the need for liberalizing American education he felt compelled to deal the severest blow to his own policy—for nothing is more needed than a better teaching and understanding of geography—by closing down the department of geography as a measure of economy. The endowment for the institute was not forthcoming and that too was closed. Only Whittlesey remained, as a university professor—he alone could not be dismissed. It would be idle to pretend that his last years at Harvard were wholly happy ones, or that the fate of his department was consistent with the great work he had done for geography. Ironically Harvard has one of the finest geographical libraries in America—largely unused. At the time of his death, however, Harvard was planning a special summer school and conference in political geography which Whittlesey was to chair, and he had just undertaken the editorship of a new series of monographs for the Association of American Geographers.

L. DUDLEY STAMP

COLONEL SIR GERALD PONSONBY LENOX-CONYNGHAM, KT., F.R.S., R.E.
1866–1956

Sir Gerald Lenox-Conyngham died in Cambridge on Saturday, 27 October 1956, in his ninety-first year; and at his death the Society lost one of its most distinguished Fellows. In 1921 he retired from the Survey of India where he had been Superintendent of the Trigonometrical Survey since 1912. He was almost immediately elected to a Fellowship at Trinity College, Cambridge, and in 1922 was appointed reader in geodesy by the university. He retired from his Readership in 1947. By this time the department of geodesy and geophysics had increased in stature, and the considerable reputation of the department is a tribute to the soundness of the foundations which he laid.

Although Sir Gerald became an international figure in the world of geodesy and geophysics, and indeed, represented His Majesty's Government at the Pan-Pacific Congresses of 1923 and 1926, he will probably be best remembered as a teacher of surveying. For a quarter of a century he lectured to a succession of classes of under-

graduates in the department of geography, many of whom later joined the various colonial survey departments. There can hardly be a department in the Commonwealth which has not numbered among its staff someone who learned from him, and there was much to learn. He was a Christian gentleman; striking in appearance, invariably courteous in his manner, uncompromising in his standards of behaviour and efficiency, but always kindly, and with a quiet humour that was never far beneath the surface. Although he reached the peak of his profession, he never forgot his early days in India; and his reminiscences of his life as a subaltern, his problems and his difficulties, coloured his teaching, so that those of us who were taught by him were fired with enthusiasm for the kind of life that he described. His humanity was wonderfully demonstrated by his delightful accounts of Indian surveyors, clerks and other assistants with whom he had worked many years previously. It was easy to see how he had earned their devotion. Many of us have found satisfaction, interest and happiness in our careers as surveyors because Sir Gerald told us what to look for and showed us how to find it.

W. W. WILLIAMS

EDWIN JAMES ORFORD

1877–1956

Edwin James Orford, who died on 28 September 1956, had been a Fellow of the Society for forty-five years, and his special contribution to its aims lay in the sphere of geography in education. He was one of those who early took part in the movement which the Society initiated when in 1887 it obtained the appointment of H. J. Mackinder at Oxford, and thus gained the recognition of geography as a study of real educational value. In 1901, Orford attended Mackinder's lectures in London and tackled the problems of adopting and adapting Mackinder's "New geography" in the almost untouched field of the elementary schools. As a thoughtful teacher, Orford realized the importance in education of utilizing the interests and also the activities of children. Hence he experimented in getting his pupils to manipulate globes in a number of ways, to make models of various kinds and to carry out simple surveys. He also took the older boys to several parts of London to see for themselves the work-places and the civic amenities of the metropolis. Such methods of teaching are now commonplace, but half a century ago they had first to be thought out, and then cooperation had to be secured from authorities not always willing to abandon old conceptions and ways.

In connection with the Geographical Association, Orford conducted excursions in town and country to suggest to other teachers how direct observation might bring to life the work in school. He gained a still wider range of influence among his contemporaries by writing a considerable number of articles in the *Geographical Teacher* and its successor *Geography* between 1907 and 1935, and also by publishing some simple text-books for school use. The writer of this notice must record his personal appreciation of Orford's assistance in devising and carrying out the practical work of undergraduate students when the University of London admitted geography as a degree subject in successive stages during the second decade of this century. With his long, varied and devoted work in the cause, Orford must be regarded as one of the pioneers of modern geography in education in this country.

J. F. UNSTEAD

CORRESPONDENCE

An English traveller in the Siegerland

During the summer of 1956 I spent some time in the Westphalian Siegerland and was therefore particularly interested in "An English traveller in the Siegerland" (*Geogr. J.* 122 (1956) 306–16). I was surprised to find that the writer made no mention of yet another of area's characteristics, namely the minute parcelling of the arable land. This feature results from the persistence of the Frankish gavelkind inheritance which must have been in operation at the time Thomas Banfield wrote and which today has become a major agricultural problem. Most of the industrial workers have their own strips of land and this means that industrial depression seldom leads to strife. It also means however that mechanization is impossible and the methods remain primitive (most of the grain and hay is still cut with scythes and 85 per cent. of the milking cows are used as draught animals) and that the routeways are encroached upon and ultimately lost. A reorganization was started in 1889 but the problem is still acute. A plan is at present being formulated by the Landwirtschaft–Kammer Westfalia–Lippe whereby the land will be redistributed as large holdings, but it is likely to be many years before this plan can be implemented and the age-old customs finally broken down.

David Hilling

University College of Wales,
Aberystwyth,

9 *October* 1956

Mr. Elkins replies as follows:

It is a great pleasure to learn that another worker from this country has been studying this fascinating region of Germany. What Mr. Hilling says about land fragmentation in the Siegerland is, of course, quite correct. In response to his surprise at my failure to deal with this subject in detail, I can only plead that I was trying to show the uniqueness of the Siegerland in the middle of the nineteenth century, and that excessive fragmentation of land holding was, and is not, alas, unique to the Siegerland, being the rule, rather than the exception, over much of western Germany.

I am, however, indebted to Mr. Hilling for his reminder that land ownership by industrial workers is still common in the Siegerland. To the disadvantages of such ownership that he gives may be added another, that the higher industrial wages become, the more such land is neglected by the owners. In the Siegerland, and in other parts of Germany where peasants have been drawn into industrial employment, the progressive abandonment of strips to rough grass or scrub has been most marked. Yet the "insurance" value of the land prevents its transfer to a full-time farmer who could make more intensive use of it. This is the problem of "social fallow" (*Sozialbrache*), "social" because the selection of strips for fallow depends on the owners' industrial employment rather than on soil fertility or accessibility. The problem is urgent in the Siegerland, where even the irrigated meadows, which depend for their maintenance on the cooperation of all adjoining owners, have been damaged. The subject has been discussed only recently in W. Hartke's article "Die 'Sozialbrache' als Phänomen der geographischen Differenzierung der Landschaft," *Erdkunde*, Band X, Heft 4, 1956.

T. H. Elkins

Department of Geography,
King's College,
London, W.C.2,

31 *January* 1956

MEETINGS: SESSION 1956–7

Meeting of 26 November 1956. Professor L. Dudley Stamp in the Chair

Paper: Evolution of the relief of the Cam valley. By B. W. Sparks

Meeting of 3 December 1956. The Rt. Hon. Lord Rennell in the Chair

Elections to Fellowship: Duncan W. L. Targett-Adams; Captain Jack T. H. Beetham; Miss Sheila M. Bell; Dr. Roland Bramley; Dr. John Brown; Peter B. Corbin; Demetrois Demetriades; The Marchioness of Downshire; Miss Sylvia A. Earle; John G. Evans; Brian D. Ferriman; Miss M. C. Fitzgerald; Simon Freedman; John G. R. Griffiths; Alun G. Jenkins; Anthony E. Harvey; John C. Jewell; Mrs. L. M. Lang; Miss Marion C. M. Lloyd; A. A. MacGregor; Alan G. Maclaine; Samuel G. Naparstek; Major J. I. Purser; Frank N. Soderlund; J. P. Randle; James Stewart; P. L. C. Wadhams; Peter G. Wood; Miss K. M. Woodhome.

Elections to Associate Membership: J. R. V. Brooks; C. W. Goodwin; W. O'H. McInnes; B. M. Willett

Paper: The military geography of Wales. By General Sir James Marshall-Cornwall

Meeting of 10 December 1956. Mr. Leonard Brooks in the Chair

Films: "Tenzing's Country" and "The R.A.F. climbing film"

Meeting of 17 December 1956. The President and Sir John Hunt, Joint Chairmen

Elections to Fellowship: Ivor C. Blake, M.A., Cantab.; W. K. Christian; Mrs. Rhoda H. Cope; Miss Julie Darby; David L. K. Faraker; E. A. W. Green; Miss E. L. S. Hall, B.A.; A. Hay; D. Hilling; G. M. Hughes, M.C., B.SC.; R. A. Kemp, M.M.; L. A. Langley, M.A., D.C.; J. W. J. Leslie; G. Lewcock; N. Moussly; N. V. Pears; J. W. Powell; J. A. Price; R. J. Price; J. A. Reeves; R. H. Rider; A. H. Roberts; I. Shatty; B. P. Sureties; Dr. P. D. Tilley

Elections to Associate Membership: C. F. T. Aub; Miss M. L. Babington; D. J. Lambourne; S. L. Rayner; Miss J. A. Turner; Miss A. Wake

Paper: Swiss ascent of Everest and Lhotse. By Albert Eggler, F. Luchsinger and H. von Gunten. Joint meeting with the Alpine Club

Meeting of 1 January 1957. The President in the Chair

Paper: Aviation and geography. By the Rt. Hon. the Lord Nathan. A joint meeting with the Geographical Association and the Institute of British Geographers

Meeting of 7 January 1957. The President in the Chair

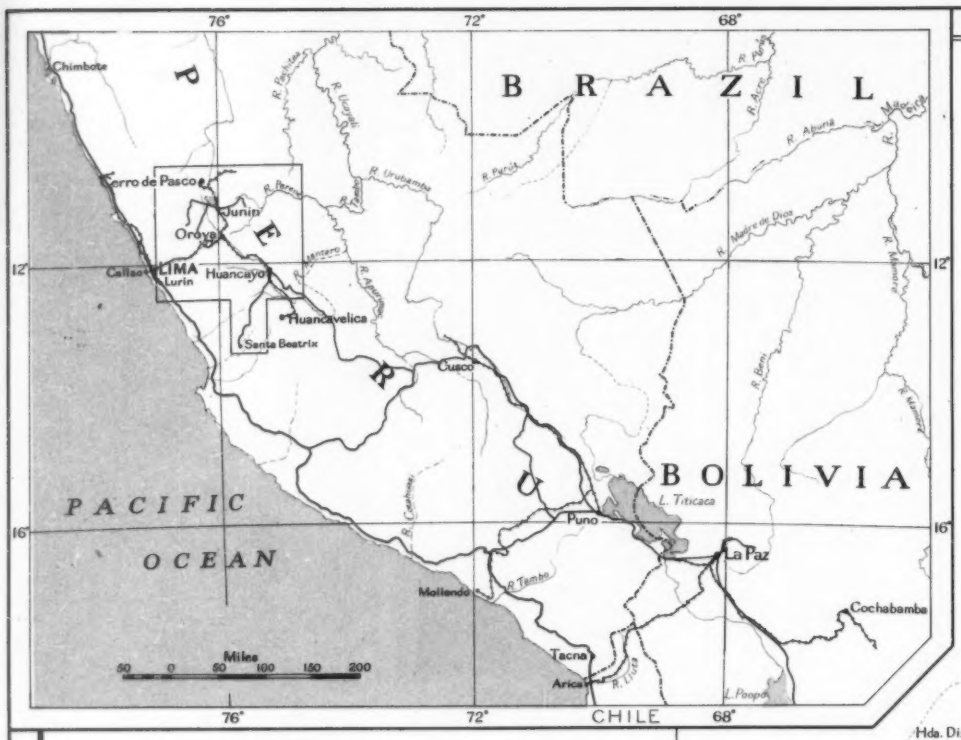
Elections to Fellowship: Edward Cook, M.A.; T. E. J. Edwards; Eric Fenton; Frank C. German; Mrs. Winifred Green; John A. Hellen; Amar Laryea; John H. Metcalfe; Miss Rosary Noblet; W. J. Roberts; David F. Spink

Elections to Associate Membership: Frank H. Flynn; Miss Margaret N. Fulcher

Paper: Oxford Expedition to Sarawak. By Guy Arnold

Meeting of 14 January 1957. Mr. Leonard Brooks in the Chair

Film: Back of beyond: a film about central Australia


76°
72°
68°
12°
16°
PERU
BRAZIL
BOLIVIA
CHILE
PACIFIC OCEAN
Chimbote
Cerro de Pasco
Junin
Oroya
Callao
LIMA
Lurin
Huancayo
Huancavelica
Santa Beatrix
Cusco
Puno
L. Titicaca
La Paz
Mollendo
Cochabamba
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Arica
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76°00'
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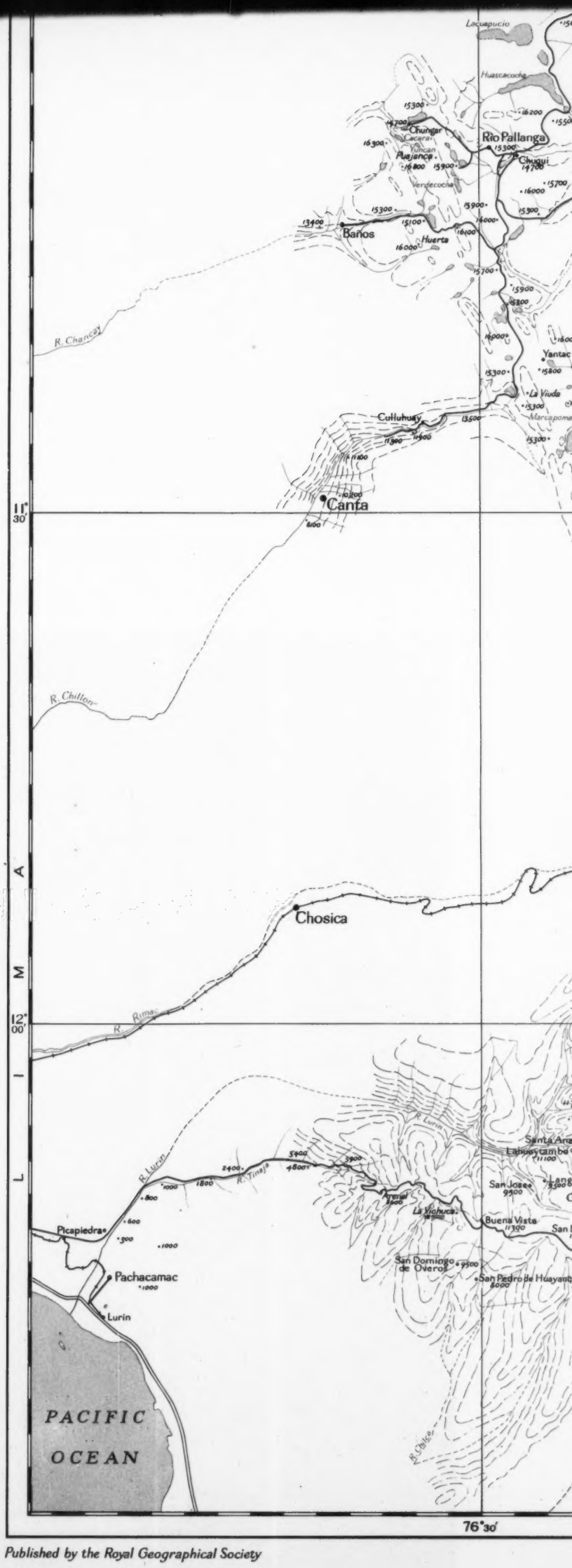
Huachon
Cuncs
Quiparacra
Guiguin
Huancas
Infernillo
Chuchurun
Rumichaca
Chupana
Algomarca
Paria
Tunancancha
Gatuncancha
Carhuacayan
Ninacaca
Tambo del Sol
Upomayo
Carhuamayo
Horno Machay
Hda. Dixmo
Pari
LAKE JUNIN
Huayre
Uco
Calcada
Ondores
San Blas
Junin
Chipian
Huallay
Rio Pallanga
Baños
Huarta
Carhuacayan
Concacancha
Chacchc
Atocsaico
La Cima
Tilarnioc
Ayabamba
Oroya
Dos Cruces
Yana Singa
Tictio
Casapalca
Mahr
Yauli
Huari
Huay Huay
Victoria
Pomacocha
San Cristobal
Rio Blanco
San Mateo
Tambo Rayan
Sortucancha
Chuicho
Piñascocha
Chosica
Nevada Tunshu
Canta
San Damian
Sunicancha
Chumpecocha
Chingulí
Santa Ana
Tinajá
R. Chancay
R. Chillon
R. Rimac
R. Lurin
11° 00'
11° 30'
12° 00'

Continuation southward on same scale

Scale 1:500,000
Miles
2 0 2 4 6 8

75°30'
75°45'
75°30'
75°15'
12° 30'
12° 45'
13° 00'
13° 15'
75°45'
75°30'
75°15'

Japaran
Cayash
S. Cristobal
Milpo
Cachiacha
Jacuhucru
Tirinata
Yanac
Chupun
Atamary
Huaman P.
Biscachayoc
Tucancha
Bisca P.
Asera Pta.
Quishia
Shanbua
Huasacocha
Cachiyoca
Huasahuasi
R. Ulcumayo
R. Tarma
R. Perene
San Ramon
R. Tulumayo
R. Tarca
Palcomayo
Acobamba
Palca
Chincha
Tapo
Tarma
Huascay
Quera
Cruces
Tarmatambo
Hda. Yuracmayo
Yuracmayo
Hda. Maco
Huaricolca
Carro de Juni
Ricran
Inca Tacuna
Puyi
Jagachaca
Cayan
Janchiscocha
Secas
Cachichechi
Chacapalpa
Pomacancha
Aricochi
Marco
Acolla
Pachacayo
R. Mantaro
Jauja
Huaqui
Huaricocha
Quiro
Conco
Carni
Huascoacha
Masnachico
Arata
Ocopa
Ingenio
Llachua Pampa
Sincos
Concepción
Acos
Huancayo
Mariscancha
Chongos
Acopalca
Alatrula
Tacshanan
Alapampa
Runatullo
Cochaisan
Jatumpucnia
Runatullo Pampa
Shyapata
Chuicon
Shaihua
Suitu Cocha
Incache
Andamarca
Pareccho Grande
Cunas
Racracalla
Huatashuai
Tamiali
Pacacancha
Lasupata
Tong Shu
Loli Concha
Condorvasha
Anas
Moras
Chonta
Shupe
Lasocuchuna
Sacuchan
Huachuas
Chincus
Alatrula
Tacshanan
Carrital
Ingue
Toldopampa
Huasancancha
Toctuga
Cochaisan
Cocha Pan
Huaricocha
Huaracayllo
Huachingacocha
Aquichancha
Santa Beatriz
Tucle Hda.
Cercapuquio
Antapongo Hda.
Huasicancha
Laive Hda.
Ingahuasi Hda.
Collarcocha
Huichicocha
Achicocha
Millococha
Huarmicocha
Astococha
Chunchoscocha
Calla
Huachingacocha
R. Tulumayo
R. Santiago
R. Satipo
R. Mantaro
R. Chocon
R. Biscacocha
R. Casca
R. Masnachico
R. Tarma
R. Chanchamayo
R. Ingenio
R. Shullcas
R. Tarma
R. Tulumayo
R. Satipo
R. Mantaro
R. Perene
R. Tarca
R. Chanchamayo
R. Ingenio
R. Shullcas



Note:—

On this topographical map the road system is incomplete. Although shown on a published map, the road as drawn from Huallay to Ondores is stated by J. V. Harrison not to exist; the road from Junin to Casca is no more than a track.

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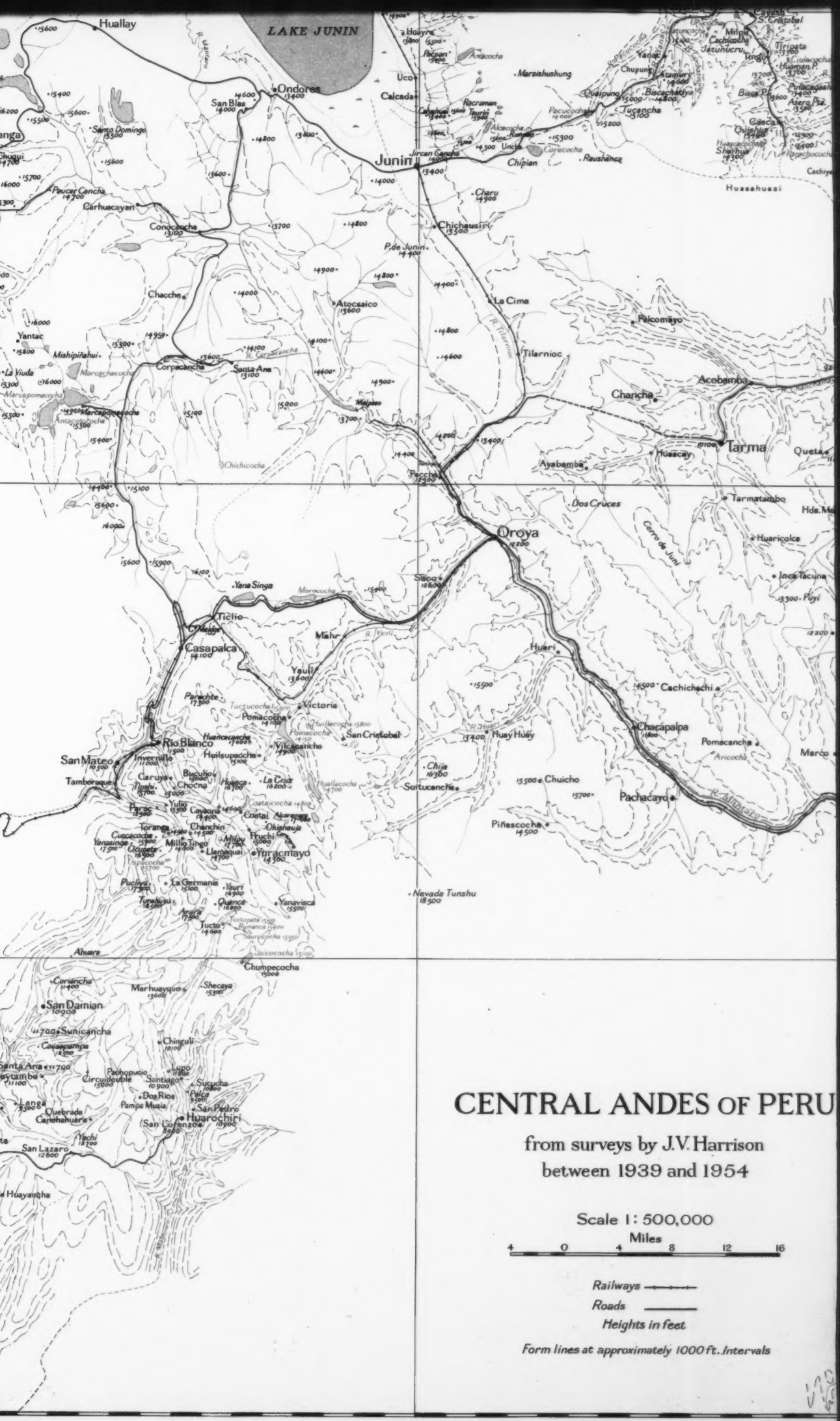
LAKE JUNIN
Huallay
Ondores
San Blas
Junin
Uco
Calcada
Maraishushung
Huayre
Pacpan
Anticocha
Racraman
Tauri
Alcacocha
Uncia
Corecocha
Chipian
Raushanca
Jircan Cancha
Charu
Chichausiri
P.de Junin
Huasahuasi
Cayash
S. Cristobal
Mirin
Cachicoha
Jacunucru
Tingo
Tirigata
Huaman P.
Yanac
Chupun
Atamuro
Quispung
Bucachattiya
Tucancha
Pucacasa
Asera Pta.
Cascas
Quishiu
Shahuay
Huascacocha
Papachococha
Cachiya
Santo Domingo
Paucar Cancha
Carhuacayan
Conococha
Chacche
Atocsaico
La Cima
Palcomayo
Tilarnioc
Yantac
Miahipiñahui
Marcachacocha
Corpacancha
Santa Ana
Marcapomacocha
Antapomacocha
Malpaso
Acobamba
Charicha
Tarma
Huasahuay
Ayabamba
Quera
Chichucocha
Pecchia
Tarmatambo
Dos Cruces
Oroya
Cerro de Juni
Huaricolca
Ines Tacuna
Puyi
Saco
Yana Singa
Morococha
Ticlio
Mahr
Casapalca
Yauli
Huari
Cachichachi
Parachite
Victoria
Pomacocha
Turtucocha
Huallacocha
San Cristobal
Huay Huay
Chacapalpa
Pomacancha
Aricoch
Marco
Rio Blanco
Huancacocha
Vilcacancha
Huilsupaccha
San Mateo
Inversillo
Tamboraque
Buicuhoy
Caruya
Chocna
Huaroca
La Cruz
Tiashi
Chija
Sortucancha
Chuicho
Pachacayo
Pañascocha
Yulio
Cayaona
Costaicocha
Okishauja
Toranga
Chanchin
Huchi
Cuscacocha
Yanasinga
Milloy
Tinyoc
Ocrueta
Ullamaqui
Yuracmayo
Ispacocha
La Germania
Yauri
Puchuy
Turuhuay
Quenca
Yanavisca
Nevada Tunshu
Anara
Tucta
Tuctopata
Rumanca
Saurococha
Jaicococha
Ahuara
Chumpecocha
Corancha
Marhuayque
Shecaya
San Damian
Sunicancha
Chinguli
Cacapampa
Santa Ana
Pachapucio
Circuitodouble
Santiago
Sucucha
Dos Rios
Palca
Lango
Quebrada
Carhahuarca
Pampa Musia
San Pedro
Huarochiri
San Lorenzo
Yachi
San Lazaro
Huayantha
CENTRAL ANDES OF PERU
from surveys by J.V. Harrison
between 1939 and 1954
Scale 1: 500,000
Miles
4 0 4 8 12 16
Railways
Roads
Heights in feet
Form lines at approximately 1000 ft. Intervals
76°00'

LAKE JUNIN

Ondores
Junin
Chichausiri
La Cima
Tilarnioc
Ayabamba
Oroya
Dos Cruces
Canta
Chosica
Baños
Río Pallanga
Chungar
Yuracmayo
Casapalca
Río Blanco
San Mateo
Huari
Huay Huay
Chuicho
Nevada Tunshu
Pachacamac
Lurin
Picapiedra
San Damian
Sunicancha
Huarochiri
San Pedro de Huayancha
San Dominigo de Olleros
Chumpecocha
Victoria
Ticlio
Mahr
Yauli
Morococha
Pomacocha
San Cristobal
Huaripampa
Pachacayo
Huancayo
Concepcion
Jauja
Tarma
Cerro de Pasco
Huanuco
Lima
Callao
Ancon
Chancay
Huacho
Supe
Barranca
Pativilca
Huaraz
Chimbote
Trujillo
Cajamarca
Chiclayo
Piura
Tumbes
Iquitos
Pucallpa
Ucayali R.
Amazon R.
Mantaro R.
Pampas R.
Apurimac R.
Urubamba R.
Titicaca L.
Cuzco
Arequipa
Mollendo
Matarani
Puno
Juliaca
Abancay
Ayacucho
Huancavelica
Ica
Nazca
Pisco
Chincha Is.
Callao
Lima
Ancon
Chancay
Huacho
Supe
Barranca
Pativilca
Huaraz
Chimbote
Trujillo
Cajamarca
Chiclayo
Piura
Tumbes
Iquitos
Pucallpa
Ucayali R.
Amazon R.
Mantaro R.
Pampas R.
Apurimac R.
Urubamba R.
Titicaca L.
Cuzco
Arequipa
Mollendo
Matarani
Puno
Juliaca
Abancay
Ayacucho
Huancavelica
Ica
Nazca
Pisco
Chincha Is.

PACIFIC OCEAN

CENTRAL AN

from surveys
between 193

Scale 1:
M
4 0 4

Railways
Roads
Height

Form lines at approxi

11° 30'
12° 00'
76°30'
76°00'

Published by the Royal Geographical Society

ANDES OF PERU

veys by J.V. Harrison
n 1939 and 1954

ale 1 : 500,000
Miles
4 8 12 16

ailways
oads
Heights in feet
approximately 1000 ft. intervals

Scale 1:500,000
Miles
2 0 2 4 6 8

San Ramon
Palcamayo
Acobamba
Palca
Chancha
Tapo
Tarma
Huasay
Queta
Hussahuasi
Cachiyaca
Tarmatambo
Hda. Yuracmayo
Yuracmayo
Hda. Maco
Huaricolca
Ricran
Jagachaca
Cayan
Janchiscocha
Inca Tacuna
Puyi
Sacas
Cachichachi
Chacapalpa
Pomacancha
Aricocha
Marco
Acolla
Pachacayo
Jauja
Masmachico
Huansali
Huajaco
Huarcacocha
Quiro
Conco
Huascococha
Carni
Arata
Ocopo
Ingenio
Sincos
Llachua Pampa
Concepcion
Aco
Ulungancha
Huancayo
Huayucachi
Viques
Pucará
Pucochobamba
Ingahuasi Hda.
Laive Hda.
Huasicancha
Antapongo Hda.
Cercapuquio
Tucle Hda.
Alapampa
Runatullo
Runatullo Pampa
Carnac
Racracalla
Huataphuasi
Tamiali
Pacacas
Lasupata
Anasi
Morococha
Chonta
Acopalca
Alotrula
Tacshanan
Chuspe
Lasocuchuna
Sacucha
Huachuca
Chances
Carrital
Ingua
Toldopampa
Hussancancha
Atoc
Toctuya
Cocohuasi
Cocha Pan
Jatumpucnia
Silvapata
Pyrico
Chuicon
Sihaihua
Tambo
Sutu Cocha
Chancha Pata
Pataccocha
Paracocha Chico
Incacha
Paracocha Grande
Andamarca
Rio Mantaro
Rio Mantaro
Rio Mantaro
Rio Mantaro
R. Tulumayo
R. Palca
R. Cascas
R. Biscacocha
R. Matahuasi
R. Yuracmayo
R. Cachicuna
R. Canipaca
R. Santa Beatriz
R. Sandia
R. Satipo
Cerro de Junin
Huachingacocha
Aquichancha
Calla
Santa Beatriz
Huamanpata
Tupacasa
Biscachatiya
Tucancha
Yanacancha
Chupuna
Atamiera
Milpo
Cachicocha
Jacunucru
Tingo
Huaman P.
Asera Pa.
Bisca Pa.
Quishuar
Shaihua
Parachococha
Tricata
Ciulacocha
Tucancha
Huascococha
Cachicocha
Huascococha
Cochapata